CANopen

User Manual

Rev. 1.1

AMP & MOONS' Automation

Introduction

This manual describes MOONS' CANopen implementation of CiA DS301 and CiA DSP402 specifications. It is expected that the user fully understands both CiA standards. That understanding, along with this specification, will enable the user to develop a distributed motion control system.

The intent of this manual is to highlight manufacturer specific requirements as they pertain to MOONS' drives.

Information and standards may be obtained from the CiA website at http://www.can-cia.com/. Information and software relating directly to the MOONS' CANopen drives, including an open-source example program, may be obtained from our website at http://www.moons.com.

Contents

Introduction 2
Reference Documents 7
Commonly Used Acronyms 7
CANopen Network Topology Overview 8
Drive Setup 8
Wiring the Power and Motor 8
Wiring the CANopen Connector for MSST5-C Drives 9
CANopen Bitrate 9
Drive Configuration 10
Supported DSP402 Modes of Operation 11
Object Dictionary 12
Electronic Data Sheet 12
Compatibility Issues 12
Global Control Word and Status Word 15
General Purpose Registers 16
Appendix A - Parameter Unit Scaling 17
Appendix B - Response Codes 18
Appendix C - Profile Position Mode 19
General Mode Description 19
Enable Profile Position Mode 19
Set Running Parameters 19
Starting/Stopping Motion 19
Appendix D - Profile Velocity Mode 24
General Mode Description 24
Enable Profile Velocity Mode 24
Set Running Parameters 24
Enable Drive Operation 24
Starting/Stopping Motion 24
Appendix E - Homing Methods 26
Set Running Parameters 26
Enable Homing Mode 26
Starting the Homing Procedure 26
Homing Method Diagrams 26
Homing Method 1 26
Homing Method 2 27
Homing Method 3 27
Homing Method 4 28
Homing Method 5 28
Homing Method 6 29

Homing Method 7 29
Homing Method 8 30
Homing Method 9 30
Homing Method 10 31
Homing Method 11 31
Homing Method 12 32
Homing Method 13 32
Homing Method 14 33
Homing Methods 15 and 16 33
Homing Method 17 34
Homing Method 18 34
Homing Methods 19 and 20 35
Homing Methods 21 and 22 36
Homing Methods 23 and 24 37
Homing Methods 25 and 26 38
Homing Methods 27 and 28 39
Homing Methods 29 and 30 40
Homing Methods 31 and 32 41
Homing Method 33 41
Homing Method 34 42
Homing Method 35 42
Appendix F - Profile Torque Mode (Servo Only) 43
General Mode Description 43
Enable Profile Torque Mode 43
Set Running Parameters 43
Enable Drive Operation 43
Starting/Stopping Torque 44
Parameter Calculations - Example 44
Current Verification - Example 44
Appendix G - Q Program Mode 46
General Mode Description 46
Loading a Q Program 46
Normal Q Program Execution 46
Synchronous Q Program Execution 47
More Information 47
Appendix H - Understanding NMT States 48
Building a CANopen NMT Data Frame - Example 48
Appendix I - SDO and PDO Access 49
Enable SDO Use 49
Building an SDO Read Data Frame - Example 49

PDO Access 49
Enable PDO Use 49
TPDO Transmission Types 50
PDO Mapping - Stepper 50
PDO Mapping - Servo 50
PDO COB-ID 51
Building an RPDO Data Frame - Example 51
Appendix J - Operation Mode Specific Control and Status Word 52
Control Word of Profile Position Mode 52
Status Word of Profile Position Mode 52
Control Word of Profile Velocity Mode 53
Status Word of Profile Velocity Mode 53
Control Word of Homing Mode 53
Status Word of Homing Mode 53
Control Word of Q Mode 54
Status Word of Q Mode 54
Appendix K – Example Programs 55
Profile Position Mode 55
Profile Velocity Mode 56
Homing Mode 56
Normal Q Mode 57
Sync Q Mode 57

List of Tables

Table 1: Bit Rate Switch Settings 10
Table 2: Modes of Operation 11
Table 3: Object Dictionary Compatibility Issues 12
Table 4: DS301 Object Descriptions 13
Table 5: DSP402 Objects 14
Table 6: Manufacturer Specific Objects 15
Table 7: User Defined Registers in CANopen and Q Programmer 16
Table 8: Parameter Scaling Chart 17
Table 9: Object $603F_h$ DSP402 Error Codes 18
Table 10: Object $700B_h$ DSP Status Codes 18
Table 11: Single Set-Point Profile Position Move 20
Table 12: Multiple Set-Point Profile Position Move with Stopping Between Moves 21
Table 13: Multiple Set-Point Profile Position Move with Continuous Motion 22
Table 14: Multi-Set-Point Profile Position Move with Immediate Change in Motion 23
Table 15: Profile Velocity Mode Example 25
Table 16: Profile Torque Mode Example 45
Table 17: Understanding NMT States 48
Table 18: Example - NMT Data Frame 48
Table 19: Enable SDO Use 49
Table 20: TPDO Transmission Types 50
Table 21: PDO Mapping - Stepper 50
Table 22: PDO Mapping - Servo 50
Table 23: PDO COB-IDs 51

List of Figures

Figure 1: CANopen Network Topology Overview 8
Figure 2: The CANopen Connector 9
Figure 3: Wiring Schematic 9
Figure 4: CANopen Drive - Motion Control Modes 11
Figure 5: Global Control Word and Status Word 15
Figure 6: Single Set-Point 20
Figure 7: Multiple Set-Points, Stopping Between Moves 21
Figure 8: Multiple Set-Points, Continuous Motion 22
Figure 9: Multiple Set-Points, Immediate Change in Motion 23
Figure 10: Profile Velocity Mode 25
Figure 11: Set Running Parameters 43
Figure 12: Profile Torque Mode 45

Reference Documents

MOONS' MSST5/10-C Data Sheet
MOONS' SV7-C Data Sheet
MOONS' MSSTAC6-C Data Sheet
CiA DS301
CiA DR303
CiA DSP402
Bosch CAN Physical Layer Specifications 2.0B
MOONS' Q Command Reference

Commonly Used Acronyms

CAN	Controller Area Network
CiA	CAN in Automation Group (Standards Body)
COB-ID	Communication Object Identification
DR	CiA Draft Recommendation
DS	CiA Draft Standard
DSP	CiA Draft Standard Proposal
EDS	Electronic Data Sheet
NMT	Network Management
OD	Object Dictionary
PDS	Power Drive System
PDO	Process Data Object
RPDO	Receive (incoming) PDO
SDO	Service Data Object
TPDO	Transmit (outgoing) PDO

CANopen Network Topology Overview

MOONS' CANopen drives can be integrated into a CANopen system with other device types as shown below.

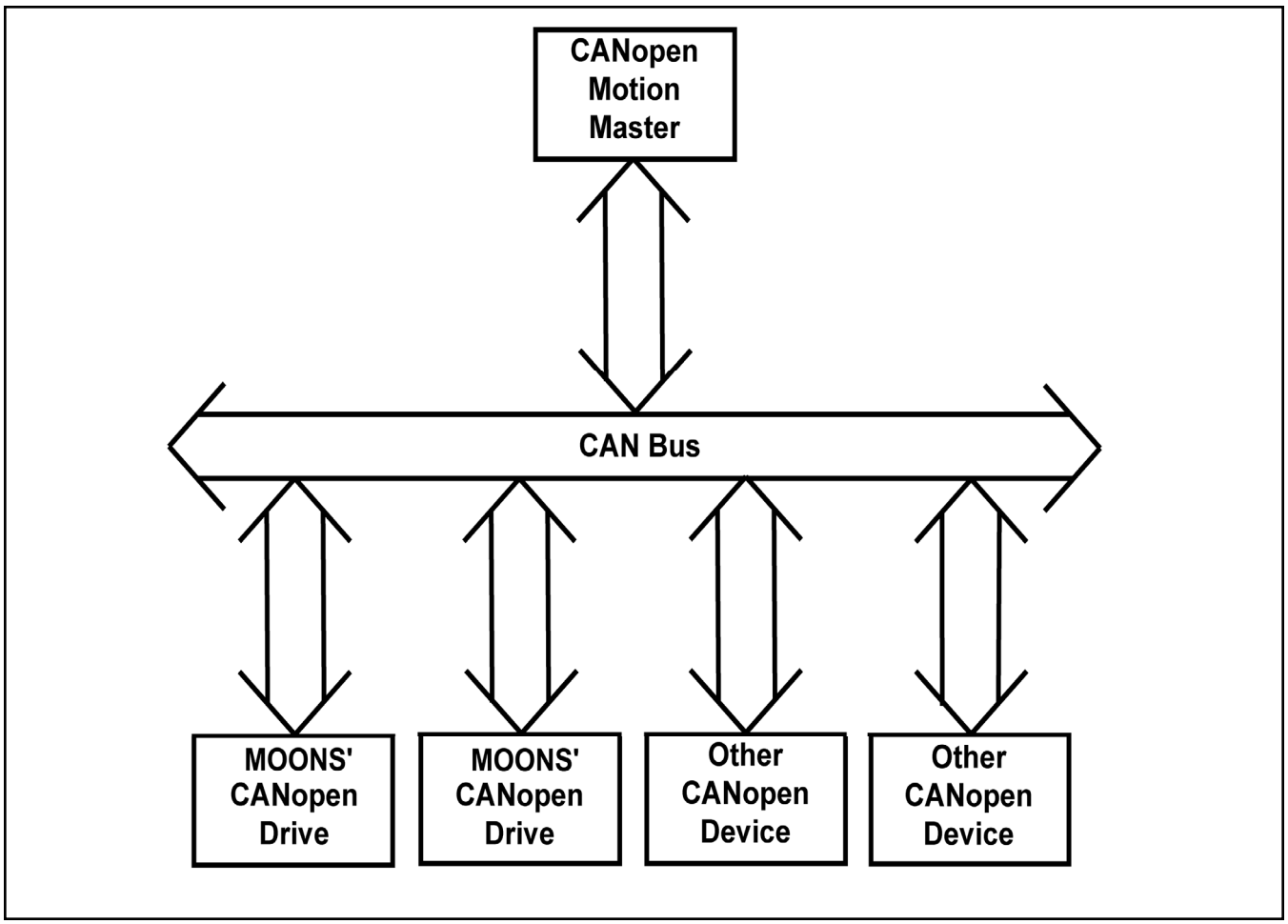


Figure 1: CANopen Network Topology Overview

Drive Setup

There are four phases to setting up a MOONS' CANopen Drive:

- Wiring the power and motor
- Wiring the CANopen connector to the drive
- Setting the Bit Rate and Node ID
- Configuring the Drive

Wiring the Power and Motor

Please refer to the drive's hardware manual for this step. The appropriate manual can be found on the CD that was included with the drive, or by visiting www.moons.com.

Wiring the CANopen Connector for MSST5-C Drives

MOONS' MSST5-C drive uses a four-pin spring connector, shown in Figure 2 below, and conforms to DR303 specification. The connector should be wired in a daisy-chain configuration, as shown in Figure 3 below, with a 120 ohm resistor used to terminate each end. Other wiring topologies, such as star networks, are not recommended due to wave reflection problems. Please reference specific hardware manuals for your drive's wiring configuration.

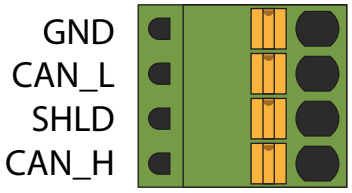


Figure 2: The CANopen Connector

Figure 3 shows a CANopen network with two MOONS' MSST5-C drive connectors wired to a Kvaser Leaf USB to CANopen Adapter.

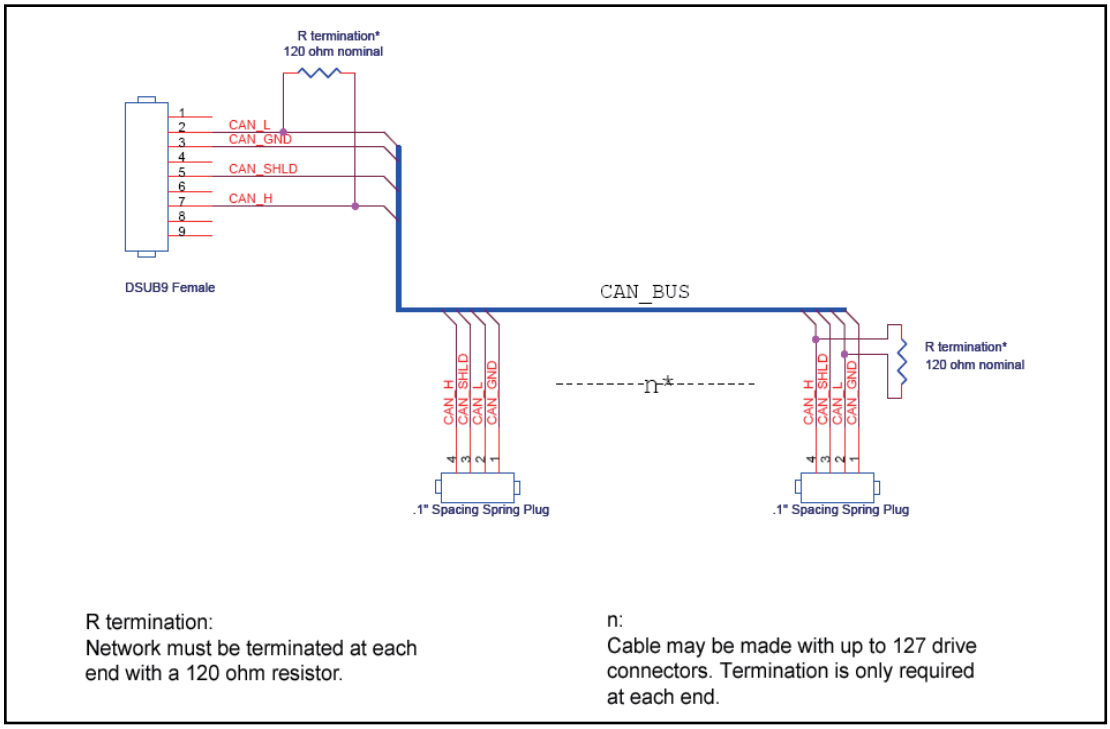


Figure 3: Wiring Schematic

CANopen Bitrate

MOONS' CANopen drives have three settings, one for Bit Rate and two for Node-ID.

The Bit Rate is configured using an 8-position switch. See Table 1 for the Bit Rate settings. Please reference the drive's hardware manual for the location of the Bit Rate switch.

The Node-ID is configured using a 16-position switch to set the lower 4 bits of the Node-ID and a 8 position switch to set the upper 3 bits of the Node-ID. In some cases, the upper 3

bits of the Node-ID are configured using ST Configurator, STAC Configurator or Quick Tuner. Please reference the drive's hardware manual for Node-ID switch configuration and setup. Valid ranges for the Node-ID are 01_h through $7F_h$. Node-ID 00_h is reserved in accordance with the DS301 specification.

Note: The Node-ID and Bit Rate are captured only after a power cycle, or after a network reset command has been sent. Changing the switches while the drive is powered on will NOT change the Node-ID until one of those conditions has also been met.

Switch Setting	Resultant Bit Rate
0	1 Mbps
1	800 kbps
2	500 kbps
3	250 kbps
4	125 kbps
5	50 kbps
6	20 kbps
7	12.5 kbps

Table 1: Bit Rate Switch Settings

Drive Configuration

Once the CAN connector has been wired to the drive, and the Node-ID and Bit Rate have been set, the drive can be configured. Drive configuration for MSST stepper drives and STM Integrated Motors is accomplished using the ST Configurator software, which can be found on the CD that was included with the drive. To configure an MSSTAC6, STAC Configurator is used. Drive configuration and tuning for servo drives are performed using Quick Tuner. In all cases the drive will need to be connected to a Windows PC using the included RS-232 serial cable. Please refer to the appropriate software manual or built-in help screens for details.

Note: When the CANopen drive is first powered on, the drive will automatically send a power-up packet over the RS-232 port. If a MOONS' application is present, it will send a response back to the drive over RS-232 and the drive will hold the CAN node in the Initialization state until the application is closed. If no response is detected, the drive will continue the normal CANopen startup procedure: the drive will power up into the Initialization state, send out a boot-up packet, move into the Pre-Operational state, and start sending out heartbeats with the Pre-Operational state as a status code.

Supported DSP402 Modes of Operation

Mode	MSST	STM	MSSTAC6	SV7
Profile Velocity	•	•	•	•
Profile Position	•	•	•	•
Homing	•	•	•	•
Profile Torque				•
Interpolated Position				
Q Program	•	•	•	•

Table 2: Modes of Operation

For detailed information on each mode see the corresponding appendix:

Profile Position Mode - Appendix C

Profile Velocity Mode - Appendix D

Homing Modes - Appendix E

Profile Torque Mode - Appendix F

Q Program Mode - Appendix G

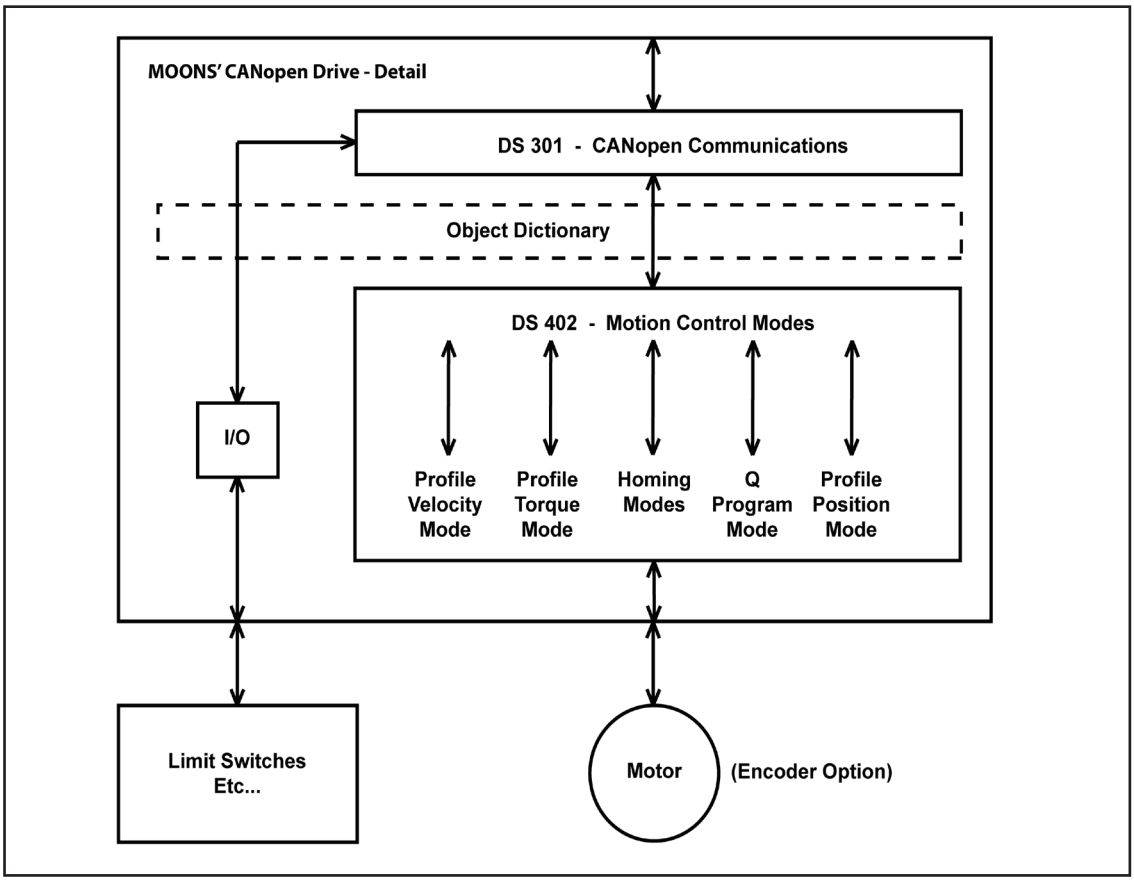


Figure 4: CANopen Drive - Motion Control Modes

Object Dictionary

The Object Dictionary (OD) is the core of any CANopen node. It provides links to all the communication and running parameters of a node. The Object Dictionary is defined in the Electronic Data Sheet (EDS), which lists all supported objects, along with any sub-objects.

Any OD Entry may be accessed using the standard Service Data Object (SDO) protocol, while some may be accessed using the low-overhead Process Data Object (PDO) protocol.

For more information: see Appendix I for a description of SDO and PDO Access

Electronic Data Sheet

The EDS, available on the CD that came with the drive or on MOONS' website, lists all the properties of every supported object in the OD.

Compatibility Issues

To maintain compatibility with the DSP402 spec, the following OD entries are defined as 32-bit values, but not all the bits will be used by the drive. The entries below should be written and read as per the CANopen Spec Length but only the Effective MOONS' Length will be used.

For example, OD entry $606C_h$ (Velocity_Target_Value) is defined as a 32-bit number, but only the lower 16 bits will be used by the drive. The upper 16 bits will be ignored, and should be left as zero when issuing a write command.

For more information: see Appendix A for a description of Parameter Unit Scaling.

Object Dictionary Entry	Object Dictionary Index	CANopen Spec Length	Effective MOONS' Length
Velocity_Target_Value	$606C_h$	32	16
Profile_Velocity	6081_h	32	16
Profile_Acceleration	6083_h	32	16
Profile_Deceleration	6084_h	32	16
Homing Speeds (multiple)	6099_h subs 1,2	32	16
Homing_Acceleration	$609A_h$	32	16
Drive Inputs	7003_h	32	8
Drive Outputs	$60FE_h$	32	8
Target_Velocity	$60FF_h$	32	16

Table 3: Object Dictionary Compatibility Issues

DS301 Object Descriptions	Comment Fields
1000_h	Device Type
1001_h	Error Register
1005_h	COB-ID Sync
1008_h	Manufacturer Device Name
$100A_h$	Manufacturer Software Revision
$100C_h$	Guard Time
$100D_h$	Life Time Factor
1017_h	Producer Heart Beat
1018_h	Identity Object
1200_h	Server SDO Parameter 0
1400_h	Receive PDO Communications Parameter 0
1401_h	Receive PDO Communications Parameter 1
1402_h	Receive PDO Communications Parameter 2
1403_h	Receive PDO Communications Parameter 3
1600_h	Receive PDO Mapping Parameter 0
1601_h	Receive PDO Mapping Parameter 1
1602_h	Receive PDO Mapping Parameter 2
1603_h	Receive PDO Mapping Parameter 3
1800_h	Transmit PDO Communications Parameter 0
1801_h	Transmit PDO Communications Parameter 1
1802_h	Transmit PDO Communications Parameter 2
1803_h	Transmit PDO Communications Parameter 3
$1A00_h$	Transmit PDO Mapping Parameter 0
$1A01_h$	Transmit PDO Mapping Parameter 1
$1A02_h$	Transmit PDO Mapping Parameter 2
$1A03_h$	Transmit PDO Mapping Parameter 3

Table 4: DS301 Object Descriptions

For more information: see DS301 for a complete description

DSP402 Objects	Comment Field
$603F_h$	Error Code - see Appendix B, Table 9, DSP Error Codes
6040_h	Controlword
6041_h	Statusword
$605A_h$	Quick Stop option code 2 & 6 only
6060_h	See section: Modes of Operation
6061_h	Modes of Operation Display
6064_h	Position Target value calculated
$606C_h$	Velocity Target value calculated
6071_h	Target Torque (servos only)
6073_h	Running Current - see Appendix A, Parameter Unit Scaling
$607A_h$	Target Position
$607C_h$	Home Offset
6081_h	Profile Velocity - see Appendix A, Parameter Unit Scaling
6083_h	Profile Acceleration - see Appendix A, Parameter Unit Scaling
6084_h	Profile Deceleration - see Appendix A, Parameter Unit Scaling
6085_h	Quick Stop Deceleration - see Appendix A, Parameter Unit Scaling
6098_h	Homing Method
6099_h	Homing Speeds - see Appendix E, Homing Methods
$609A_h$	Homing Acceleration - see Appendix E, Homing Methods
$60FE_h$	Drive Outputs
$60FF_h$	Target Velocity - see Appendix D, Profile Velocity Mode
6502_h	Supported Drive Modes

Table 5: DSP402 Objects

Manufacturer Specific Objects	Comment Field
7001_h	Home Switch Select 01_h thru 06_h
7002_h	Idle Current - See Appendix A: (For Scaling)
7003_h	Display Drive Inputs
7007_h	Q Sequence Number Select 1 thru 12
7009_h	Velocity Actual Value - Calculated via Motor Encoder - Appendix A
$700A_h$	Position Actual Value - Calculated via Motor Encoder
$700B_h$	DSP Status Code - see Appendix B, Table 10
$700C_h$	Acceleration_Current - See Appendix A: (For Scaling)
$700E_h$	Analog Input 1
$700F_h$	Analog Input 2

Table 6: Global Control Word and Status Word

Global Control Word and Status Word

<table>
<tr><th rowspan="2">Byte #</th><th rowspan="2">Bit #</th><th colspan="5">Control Word</th><th colspan="5">Status Word</th></tr>
<tr><th>Homing</th><th>Position</th><th>Velocity</th><th>Torque</th><th>Q</th><th>Homing</th><th>Position</th><th>Velocity</th><th>Torque</th><th>Q</th></tr>
<tr><td rowspan="10">1</td><td>15</td><td colspan="5" rowspan="5">Reserved</td><td colspan="5">Reserved</td></tr>
<tr><td>14</td></tr>
<tr><td>13</td><td>Homing Error</td><td>Following Error</td><td>Reserved</td><td>Reserved</td><td>Reserved</td></tr>
<tr><td>12</td><td>Homing Attained</td><td>Set Point Ack</td><td>Speed</td><td>Reserved</td><td>Reserved</td></tr>
<tr><td>11</td><td colspan="5">Internal Limit Active</td></tr>
<tr><td>10</td><td colspan="5" rowspan="2">Target Reached</td></tr>
<tr><td>9</td><td>Reserved</td><td>Change of Set Point</td><td>Reserved</td><td>Reserved</td><td>Reserved</td></tr>
<tr><td>8</td><td colspan="5">Halt</td><td colspan="5">Reserved</td></tr>
<tr><td rowspan="10">2</td><td>7</td><td colspan="5">Fault Reset</td><td colspan="5">Warning</td></tr>
<tr><td>6</td><td>Reserved</td><td>Abs/Rel</td><td>Reserved</td><td>Reserved</td><td>Reserved</td><td colspan="5">Switch On Disabled</td></tr>
<tr><td>5</td><td>Reserved</td><td>Change Set Point Immediately</td><td>Reserved</td><td>Reserved</td><td>Reserved</td><td colspan="5">Quick Stop</td></tr>
<tr><td>4</td><td>Homing Operation Start</td><td>New Set Point</td><td>Reserved</td><td>Reserved</td><td>Q Program Start</td><td colspan="5">Voltage Enabled</td></tr>
<tr><td>3</td><td colspan="5">Enable Operation</td><td colspan="5">Fault</td></tr>
<tr><td>2</td><td colspan="5">Quick Stop</td><td colspan="5">Operation Enabled</td></tr>
<tr><td>1</td><td colspan="5">Enable Voltage</td><td colspan="5">Switched On</td></tr>
<tr><td>0</td><td colspan="5">Switch On</td><td colspan="5">Ready to Switch On</td></tr>
</table>

Figure 5: Global Control Word and Status Word

General Purpose Registers

MOONS' CANopen products provide 23 general purpose registers. These registers are 32 bit read/write registers. They are volatile, so the information sent there will not be saved after a power cycle.

These registers may also be accessed and manipulated via a stored Q Program, if desired. The table below cross-references the CANopen OD entries and the Q Programmer register addresses.

For more information on using these general purpose registers in a Q Program, please see the Q Command Reference, available at www.moons.com.

For more information about the Q Program Mode: see Appendix G

Register Name	OD Address	Q Register Address
User Defined Register 0	4000_h	0
User Defined Register 1	4001_h	1
User Defined Register 2	4002_h	2
User Defined Register 3	4003_h	3
User Defined Register 4	4004_h	4
User Defined Register 5	4005_h	5
User Defined Register 6	4006_h	6
User Defined Register 7	4007_h	7
User Defined Register 8	4008_h	8
User Defined Register 9	4009_h	9
User Defined Register 10	$400A_h$	:
User Defined Register 11	$400B_h$	;
User Defined Register 12	$400C_h$	<
User Defined Register 13	$400D_h$	=
User Defined Register 14	$400E_h$	>
User Defined Register 15	$400F_h$	?
User Defined Register 16	4010_h	@
User Defined Register 17	4011_h	[
User Defined Register 18	4012_h	\
User Defined Register 19	4013_h	]
User Defined Register 20	4014_h	^
User Defined Register 21	4015_h	_
User Defined Register 22	4016_h	`

Table 7: User Defined Registers in CANopen and Q Programmer

Appendix A - Parameter Unit Scaling

The table below shows conversions from physical units to internal drive units. Use this table to scale parameters before they are sent to the drive. Units must be rounded to the nearest whole number and represented in hexadecimal. Negative numbers should be expressed using two's complement notation.

Parameter Type	Multiplier	Units
Current	0.01	A
Velocity	0.0042	rps
Acceleration	0.1667	rps/s
Distance	1	step

Table 8: Parameter Scaling Chart

Querying the Point to Point Profile Acceleration from the drive:

An SDO read from OD 6083_h returns a value of 226_h, or 550 decimal. Using the acceleration multiplier this yields an acceleration of 91.685 rps/s.

550 * 0.1667 RPS = 91.685 rps/s

Set the Point to Point Acceleration to 10 rps:

When setting a known rps, divide the rps by the acceleration multiplier to obtain the hexadecimal number.

10 rps / 0.1667 = 59.988

Using the formula above, and rounding to the nearest whole number, results in a value of 60 decimal, or $3C_h$ to send as an SDO Write to OD 6083_h.

Set the Target Position to -2000 steps:

Because the relationship between physical steps and internal steps is one-to-one, the value -2000 can be sent to OD $607A_h$. Sending a negative number must be done in two's complement notation. To find the two's complement, subtract the value 2000 from 2^{32}, since the Target Position is a 32 bit number.

2^{32} - 2000 = 4,294,965,296 = $FFFFF830_h$

Appendix B - Response Codes

Hex Value	SV7	MSSTAC6	MSST	STM
0001	***Position Limit***			
0002	CCW Limit			
0004	CW Limit			
0008	***Over Temp***			
0010	***Internal Voltage***	***Excess Regen***	***Internal Voltage***	***Internal Voltage***
0020	***Over Voltage***			
0040	Under Voltage	***Under Voltage***	Under Voltage	Under Voltage
0080	***Over Current***			
0100	***Bad Hall Sensor***	***Open Motor Winding***		
0200	***Bad Encoder***			Not Used
0400	Comm Error			
0800	Bad Flash			
1000	Wizard Failed	No Move		
2000	Current Foldback	Motor Resistance Out of Range	Not Used	Not Used
4000	Blank Q Segment			
8000	No Move	Not Used		

Note: Items in ***bold italic*** represent Drive Faults, which automatically disable the motor. Use the OF command in a Q Program to branch on a Drive Fault.

Table 9: Object $603F_h$ DSP402 Error Codes

Hex Value	Status Code Bit Definition
0001	Motor Enabled - motor disabled is this bit = 0
0002	Sampling - for Quick Tuner
0004	Drive Fault - check alarm code
0008	In Position - motor is in position
0010	Moving - motor is moving
0020	Jogging - currently in jog mode
0040	Stopping - in the process of stopping from a stop command
0080	Waiting - for an input
0100	Saving - parameter data is being saved
0200	Alarm present - check alarm code
0400	Homing - executing an SH command
0800	Wait Time - executing a WT command
1000	Wizard running - timing wizard is running
2000	Checking encoder - timing wizard is running
4000	Q Program is running
8000	Initializing

Table 10: Object $700B_h$ DSP Status Codes

Appendix C - Profile Position Mode

General Mode Description

Profile Position Mode is a point-to-point operating mode using set-points which consist of velocity, acceleration, deceleration, and target position. Once all these parameters have been set, the drive buffers the commands and begins executing the set-point. When using a set of set-points method, a new set-point can be sent to the drive while a previously sent set-point is still executing.

Enable Profile Position Mode

To enable the Profile Position Mode, the value 0001_h must be written to the mode of operation OD entry, located at dictionary address 6060_h. The mode of operation can be verified using OD 6061_h - mode of operation display - which is updated when the current operation mode is accepted.

Set Running Parameters

Set the distance, velocity, acceleration, and deceleration using OD entries $607A_h$, 6081_h, 6083_h, and 6084_h respectively.

Starting/Stopping Motion

After power up or node reset, the drive is in disabled state. The value 0006_h must be written to the control word OD entry, located at dictionary address 6040_h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006_h is not written to the control word first, the drive operation can not be enabled.

To indicate a new set-point and start motion, toggle bit 4 by sending $001F_h$ to controlword OD entry 6040_h.

To enable drive operation, the value $001F_h$ must be written to the controlword OD entry, located at dictionary address 6040_h. This will also signal that there is a new set-point ready. The drive acknowledges the receipt of a valid set-point using bit 12 of the statusword at OD 6041_h. Because the set-point is edge-triggered, once the drive receives and processes the set-point, the new set-point of the controlword must be cleared by writing $000F_h$ to the controlword register.

While the drive is acting on a set-point, a new set-point may be entered and triggered using the new set-point. The second set-point will be received as soon as it is processed, or at the end of the previous set-point, which ever is later.

Controlword Bits

New Set-point (bit 4) - set this bit high to clock in a new set-point. Once the drive has accepted the set-point, it will respond by setting statusword bit 12 high. Controlword bit 4 should then be taken low.

Change of Set-point (bit 9) - if this bit is low, the previous set-point will be completed and the motor will come to rest before a new set-point is processed. If bit 9 is high, the motor will continue at the speed commanded by the previous set-point until it has reached the position commanded by the previous set-point, then transition to the speed of the new set-point.

Change Set-point Immediately (bit 5) - if this bit is high, the new set-point will take effect immediately. The motor speed will transition to the speed and position commanded by the new set-point.

Abs/rel (bit 6) - if this bit is high, the set-point distance is relative. For example, if the previous motor position was 10,000 steps and a new set-point is issued with a distance of 20,000, the final position will be 30,000. If bit 6 is low, the distance is absolute. If the previous motor position was 10,000 and a new set-point is issued with a distance of 20,000, the new position will be 20,000. (The distance travelled from the previous position to the new position will be 10,000 steps.) For best results, do not

change this bit while the motor is moving.

Note: Two set-points can be set up, but if status bit 12 is high, then the buffer is full and another set-point will be ignored.

For more information: See DSP402 - 2, Profile Position Mode

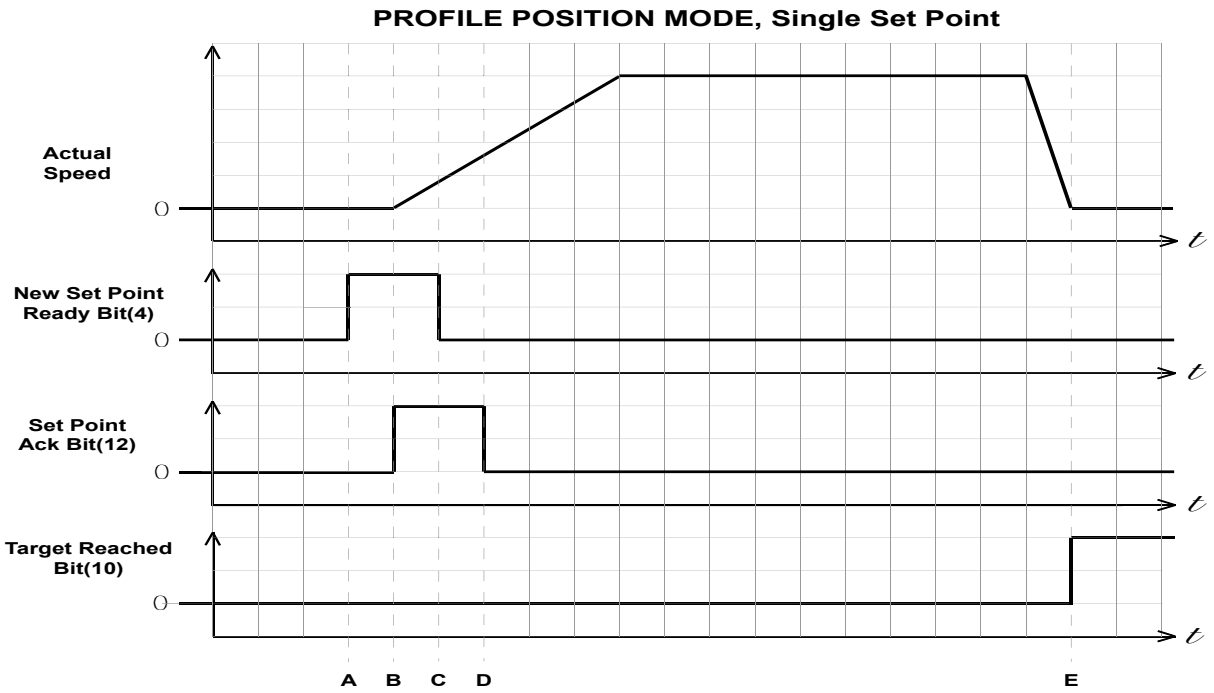


Figure 6: Single Set-Point

Graph Point	New Set-Point Ready Bit	Set-Point Acknowledge Bit	Target Reached Bit	What's Going On
Start	0	0	0	Drive waiting for set-point
A	0 -> 1	0	0	User tells drive a set-point is ready
B	1	0 -> 1	0	Drive acknowledges set-point, starts executing set-point
C	1 -> 0	1	0	User pulls new set-point ready bit low
D	0	1 -> 0	0	Drive pulls set-point ack bit low, indicating ready to receive another set-point
E	0	0	1	The set-point is finished, and the Target Reached bit is set

Table 11: Single Set-Point Profile Position Move

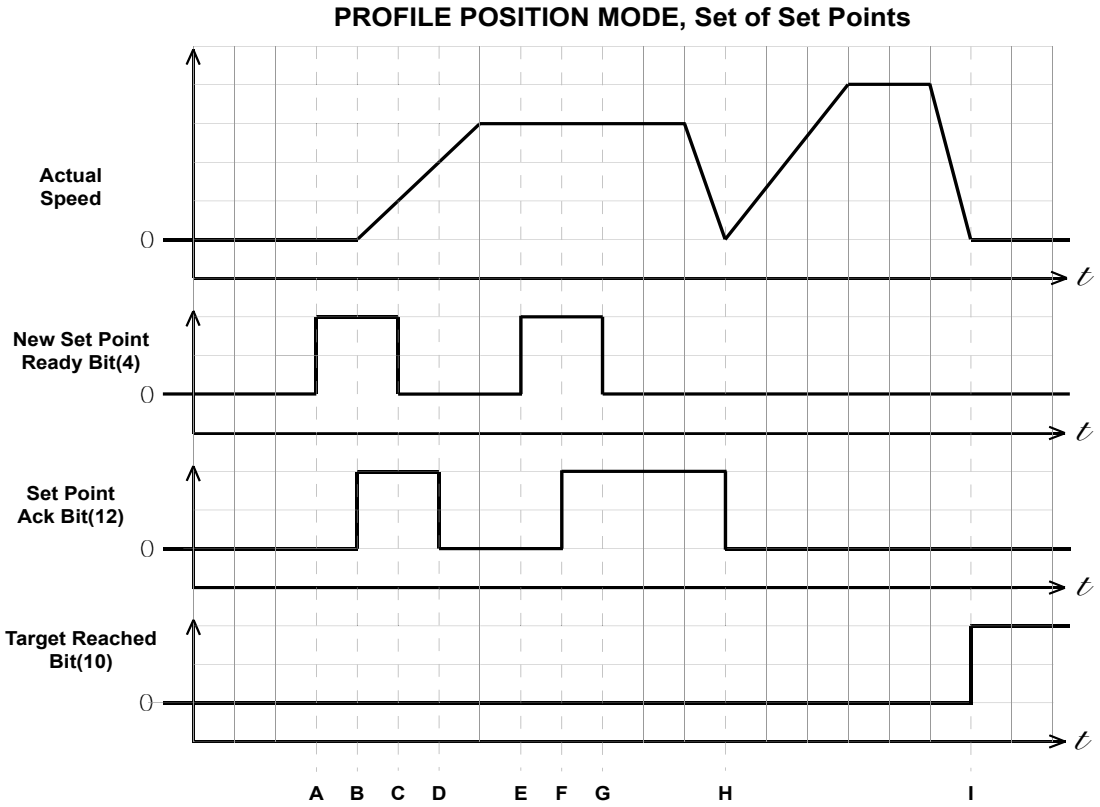


Figure 7: Multiple Set-Points, Stopping Between Moves

In this example, controlword bits 9 (Change of Set-point) and 5 (Change Set Immediately) are 0. The motor comes to rest between moves.

Graph Point	New Set-Point Ready Bit	Set-Point Acknowledge Bit	Target Reached Bit	What's Going On
Start	0	0	0	Drive waiting for set-point
A	0 -> 1	0	0	User tells drive a set-point is ready
B	1	0 -> 1	0	Drive acknowledges set-point, starts executing set-point
C	1 -> 0	1	0	User pulls new set-point ready bit low
D	0	1 -> 0	0	Drive pulls set-point ack bit low, indicating ready to receive another set-point
E	0 -> 1	0	0	User tells drive another set-point is ready
F	1	0 -> 1	0	Drive acknowledges set-point, buffers it as another set-point is still in progress
G	1 -> 0	1	0	User pulls new set-point ready bit low
H	0	1 -> 0	0	Drive pulls set-point ack bit low, starts executing new set-point as soon as old one is finished
I	0	0	1	The set-point is finished, no set-points in buffer, so Target Reached bit is set

Table 12: Multiple Set-Point Profile Position Move with Stopping Between Moves

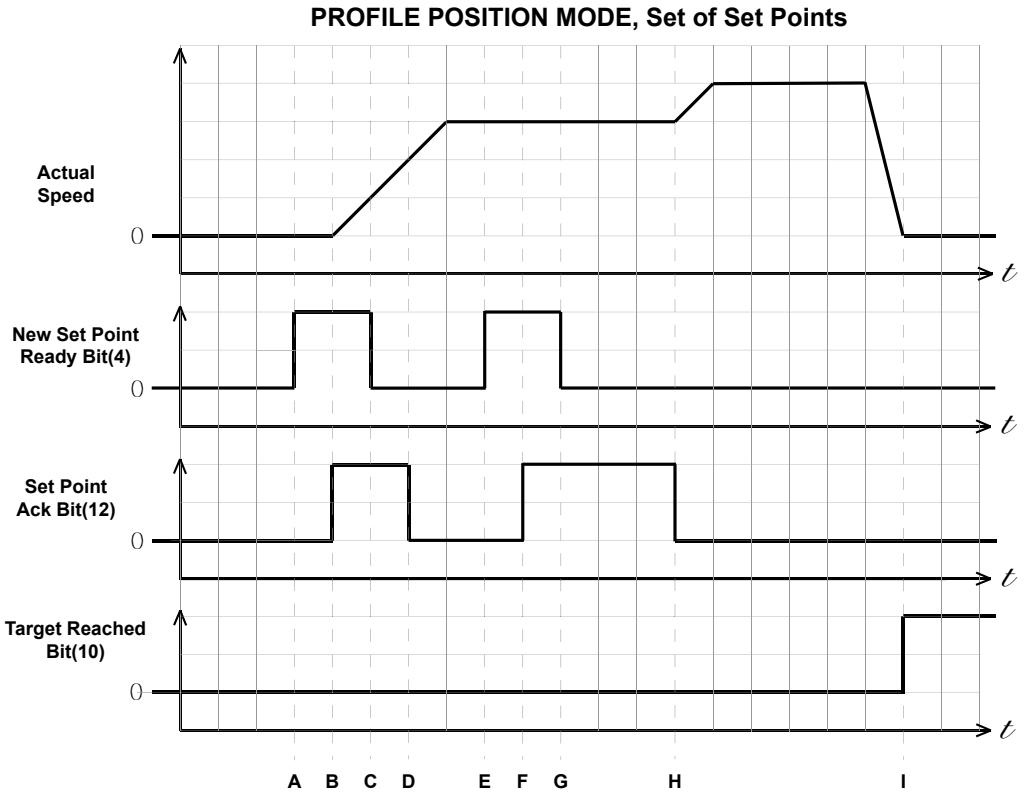


Figure 8: Multiple Set-Points, Continuous Motion

In this example, controlword bit 9 (Change of Set-point) is 1 and controlword bit 5 (Change Set Immediately) is 0. The motor continues at the speed of the first set-point until is reaches the distance of the first set-point, then changes to the new set-point speed. The motion is continuous.

Graph Point	New Set-Point Ready Bit	Set-Point Acknowledge Bit	Target Reached Bit	What's Going On
Start	0	0	0	Drive waiting for set-point
A	0 -> 1	0	0	User tells drive a set-point is ready
B	1	0 -> 1	0	Drive acknowledges set-point, starts executing set-point
C	1 -> 0	1	0	User pulls new set-point ready bit low
D	0	1 -> 0	0	Drive pulls set point ack bit low, indicating ready to receive another set-point
E	0 -> 1	0	0	User tells drive another set-point is ready
F	1	0 -> 1	0	Drive acknowledges set-point, buffers it, as another set-point is still in progress
G	1 -> 0	1	0	User pulls new set-point ready bit low
H	0	1 -> 0	0	Drive pulls set-point ack bit low, starts executing new set-point as soon as the old one is finished
I	0	0	1	The set-point is finished, no set-points in buffer, so Target Reached bit is set

Table 13: Multiple Set-Point Profile Position Move with Continuous Motion

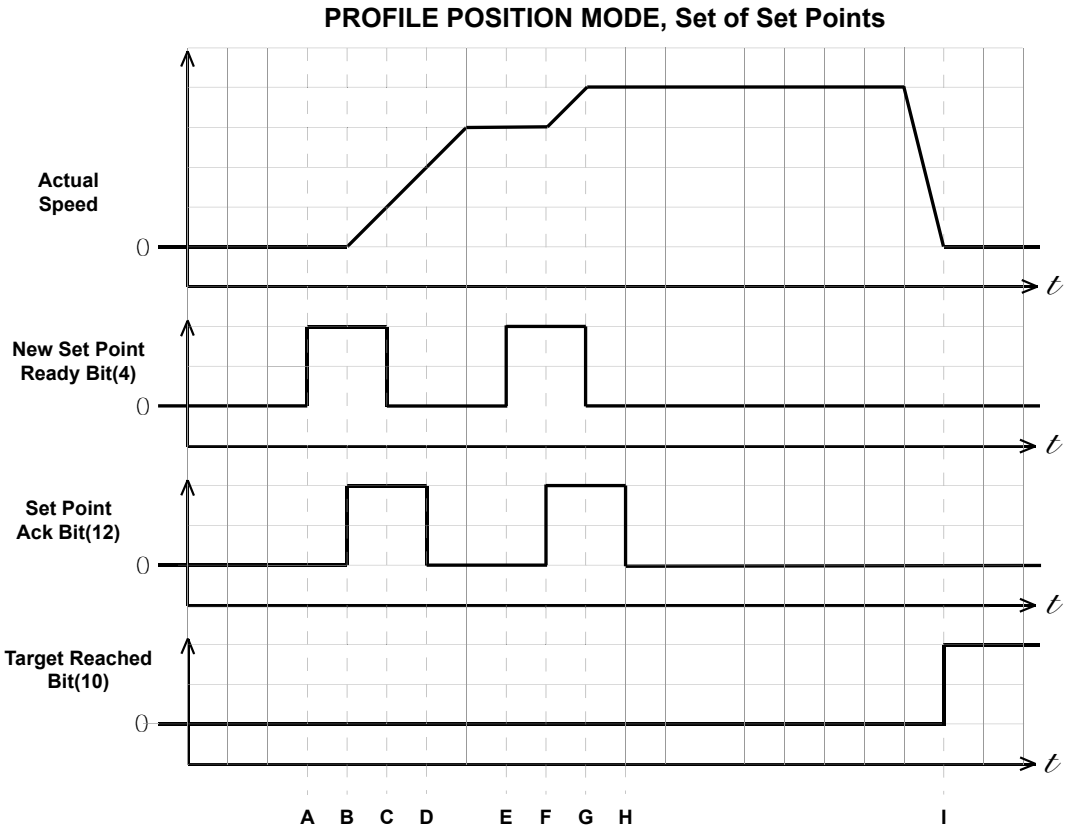


Figure 9: Multiple Set-Points, Immediate Change in Motion

In this example, controlword bit 9 (Change of Set-point) is 1 and controlword bit 5 (Change Set Immediately) is 1. The motor immediately changes to the new set-point speed without completing the first set-point. The motion is continuous.

Graph Point	New Set Point Ready Bit	Set-Point Acknowledge Bit	Target Reached Bit	What's Going On
Start	0	0	0	Drive waiting for set-point
A	0 -> 1	0	0	User tells drive a set-point is ready
B	1	0 -> 1	0	Drive acknowledges set-point, starts executing set-point
C	1 -> 0	1	0	User pulls new set-point ready bit low
D	0	1 -> 0	0	Drive pulls set point ack bit low, indicating ready to receive another set-point
E	0 -> 1	0	0	User tells drive another set-point is ready
F	1	0 -> 1	0	Drive acknowledges set-point, immediately executes it, beginning transition to new set-point speed and position
G	1 -> 0	1	0	User pulls new set-point ready bit low
H	0	1 -> 0	0	Drive pulls set-point ack bit low
I	0	0	1	The set-point is finished, no set-points in buffer, so Target Reached bit is set

Table 14: Multi-Set-Point Profile Position Move with Immediate Change in Motion

Appendix D - Profile Velocity Mode

General Mode Description

Profile Velocity Mode is a relatively simple operating mode. Once the velocity, acceleration, and deceleration are set, the drive will either command the motor to accelerate to the running velocity according to the acceleration parameter, or to halt movement according to the deceleration parameter.

The figure below shows an example of Profile Velocity Mode. The top graph shows the actual speed of the motor, the middle graph the target speed value, and the bottom graph the halt bit in the controlword.

The table below explains how the halt bit and target velocity may be used together to affect motor speed. Between points B and C, the motor does not come to a complete stop, but decelerates according to the profile deceleration value starting at point B. When the halt bit transitions at point C, it accelerates immediately back to the target speed. At Point E, reducing the target speed to zero has the same effect as enabling the halt bit, since the drive is commanding the motor to move at zero speed.

It should be noted that both enabling the halt bit and setting the target velocity to zero keep torque applied to the motor. In order to allow the shaft to move freely, the NMT state must be put in the Drive Disabled state.

Enable Profile Velocity Mode

To enable the profile velocity mode, the value 0003_h must be written to the mode of operation OD entry, located at dictionary address 6060_h.

The mode of operation can be verified using OD 6061_h - mode of operation display - which is updated when the current operation mode is accepted.

Set Running Parameters

Set the velocity, acceleration, and deceleration using OD entries $60FF_h$, 6083_h, and 6084_h respectively.

Enable Drive Operation

After power up or node reset, the drive is in disabled state. The value 0006_h must be written to the control word OD entry, located at dictionary address 6040_h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006_h is not written to the control word first, the drive operation can not be enabled.

To enable drive operation, the value $010F_h$ must be written to the controlword OD entry, located at dictionary address 6040_h. This puts the drive into Operation Enabled state, with the motion halted.

Starting/Stopping Motion

To start and stop motion, toggle the controlword halt bit (bit 8). When the halt bit is set to 0, motion will start or continue; when the halt bit is set to 1, motion will stop. The bit can be toggled by writing $010F_h$ and $000F_h$ to controlword OD entry 6040_h.

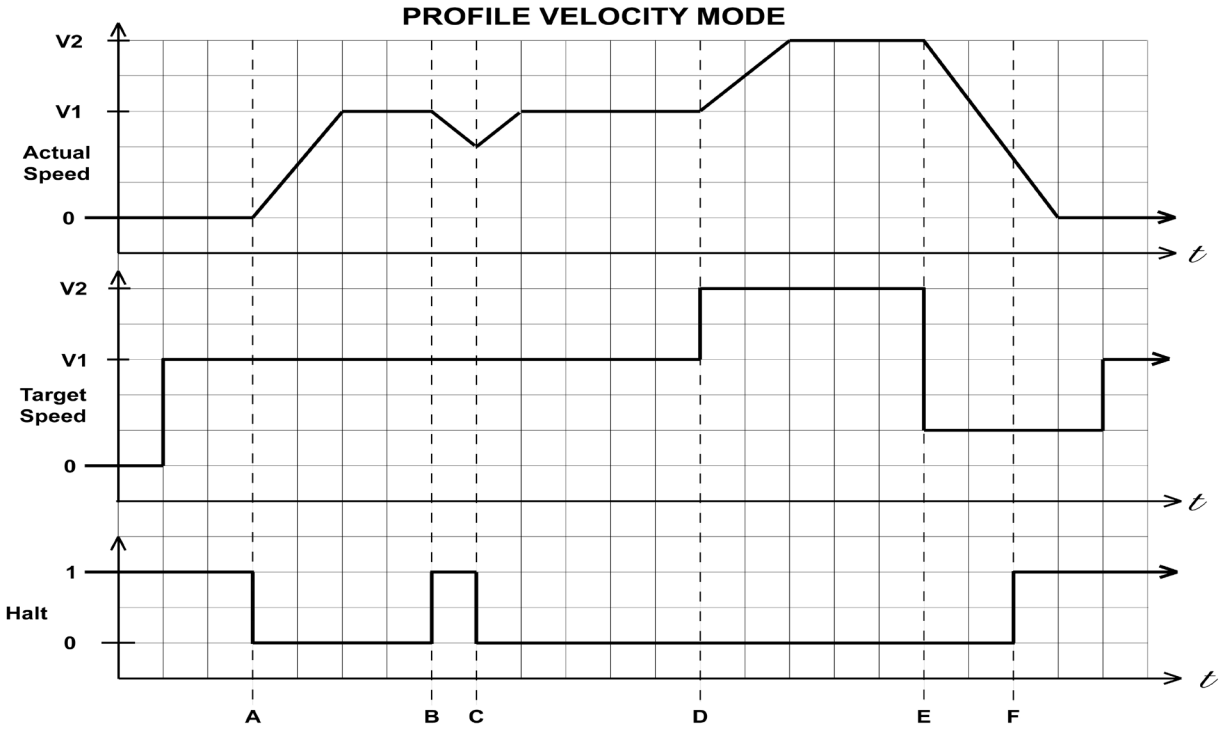


Figure 10: Profile Velocity Mode

Graph Point	Target Speed	Halt Bit	Drive command to Motor
Start	0	1	Motor stopped
A	V1	1 -> 0	Motor accelerates to speed V1
B	V1	0 -> 1	Motor decelerates to stopped
C	V1	1 -> 0	Motor accelerates to V1
D	V1 -> V2	0	Motor accelerates from V1 to V2
E	V2 -> 0	0	Motor decelerates from V2 to 0
F	0	0 -> 1	Motor remains stopped
G	0 -> V1	1	Motor remains stopped

Table 15: Profile Velocity Mode Example

Appendix E - Homing Methods

Set Running Parameters

Set the homing and index velocities, acceleration/deceleration, offset and home sensor (if required) using OD entries 6099_h, $609A_h$, $607C_h$, and 7001_h respectively.

Note: It is important that the limit switch settings have been defined in ST Configurator or Quick Tuner prior to using the CANopen Homing Mode.

Enable Homing Mode

To enable Homing Mode, the value 0006_h must be written to the mode of operation OD entry, located at dictionary address 6060_h. The mode of operation can be verified using OD 6061_h - mode of operation display - which is updated when the current operation mode is accepted.

After power up or node reset, the drive is in disabled state. The value 0006_h must be written to the control word OD entry, located at dictionary address 6040_h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006_h is not written to the control word first, the drive operation can not be enabled.

To put the drive into Operation Enabled Mode, write $000F_h$ to the controlword OD entry, located at dictionary address 6040_h.

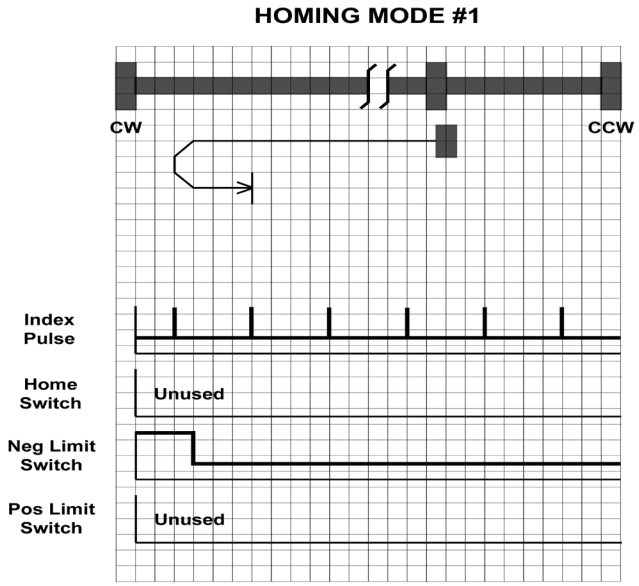
Starting the Homing Procedure

Set the Homing Method required using OD entry 6098_h. To start the homing procedure, bit 4 of the controlword OD entry located at dictionary address 6040_h, must transition from 0 to 1. The status of the homing procedure can be monitored using the statusword OD entry 6041_h.

Homing Method Diagrams

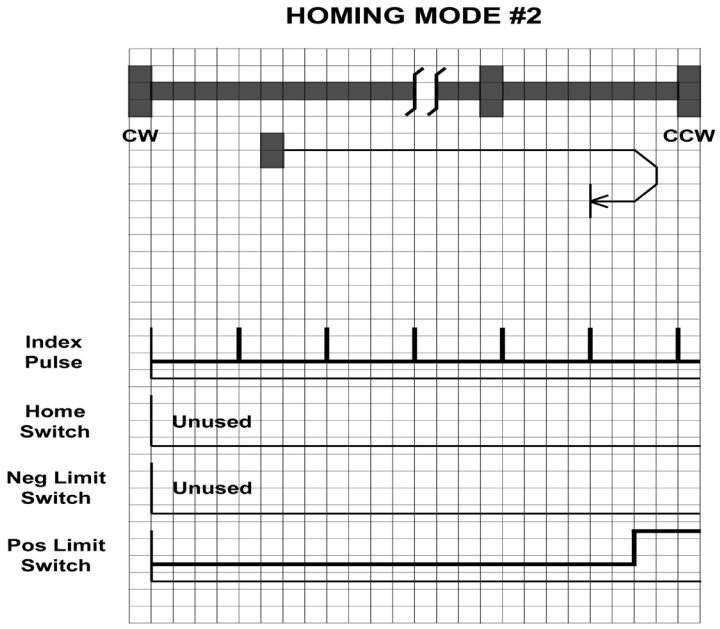
Homing Method 1

Homes to the first index CCW after the CW limit switch is reached.



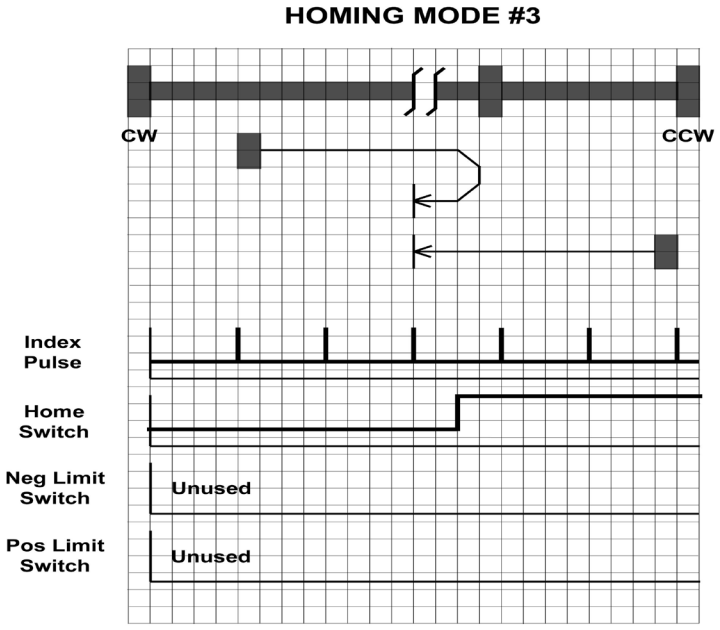
Homing Method 2

Homes to the first index CW after the CCW limit switch is reached.



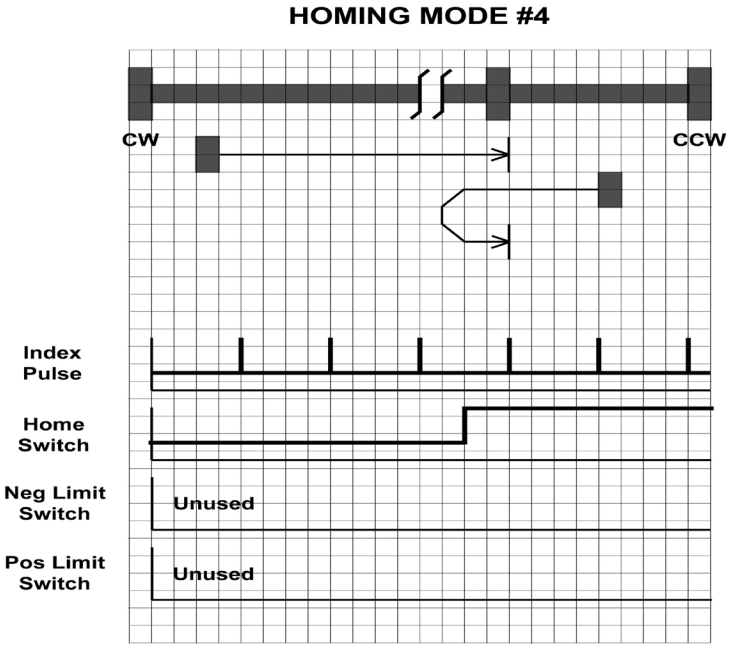
Homing Method 3

Homes to the first index CW after the positive home switch changes state; the initial direction of motion is dependent on the state of the home switch.



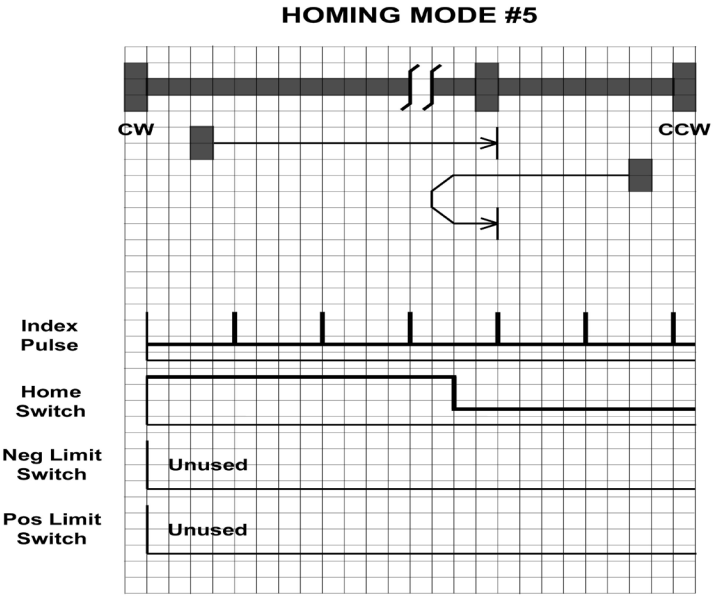
Homing Method 4

Homes to the first index CCW after the positive home switch changes state; the initial direction of motion is dependent on the state of the home switch.



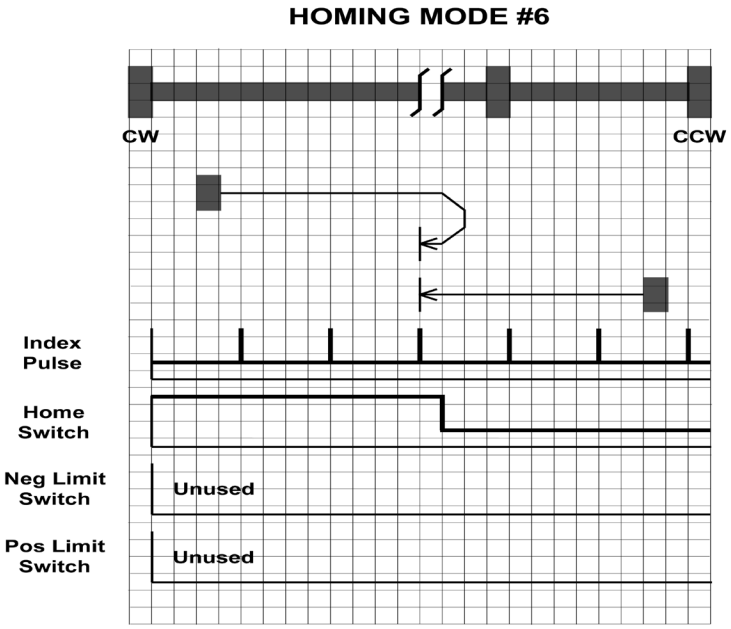
Homing Method 5

Homes to the first index CCW after the negative home switch changes state; the initial direction of motion is dependent on the state of the home switch.



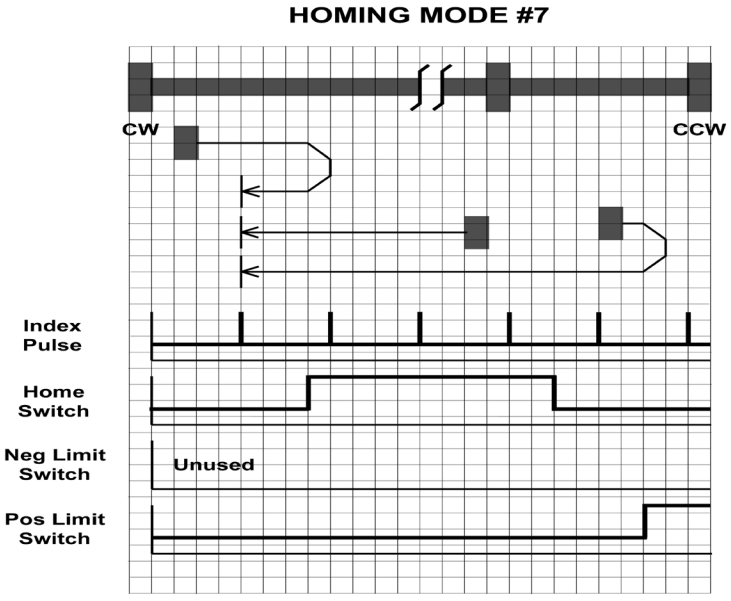
Homing Method 6

Homes to the first index CW after the negative home switch changes state; the initial direction of motion is dependent on the state of the home switch.



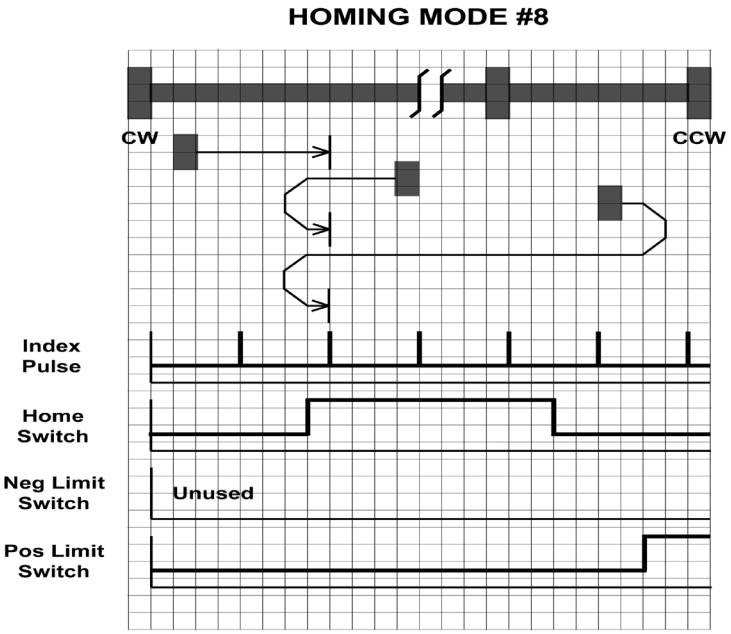
Homing Method 7

Starts moving CCW (or CW if the home switch is active), and homes to the first index CW of the home switch transition.



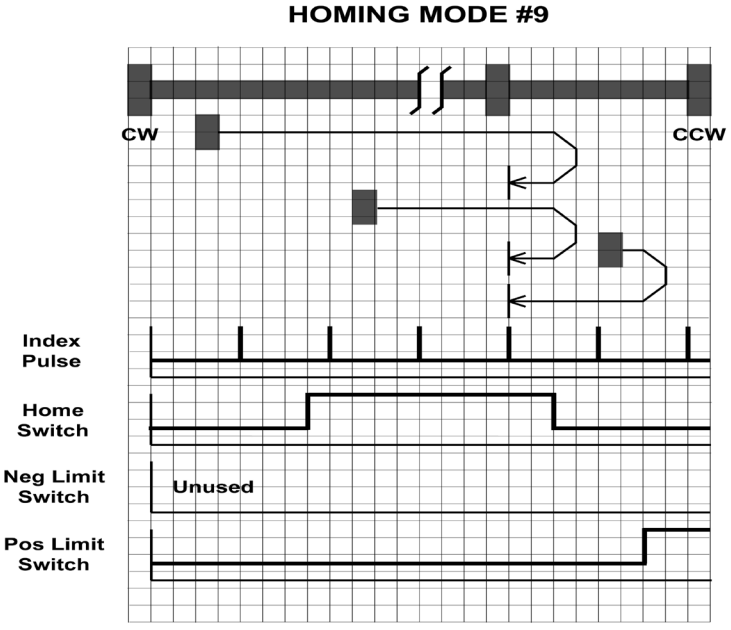
Homing Method 8

Starts moving CCW (or CW if the home switch is active), and homes to the first index CCW of the home switch transition.



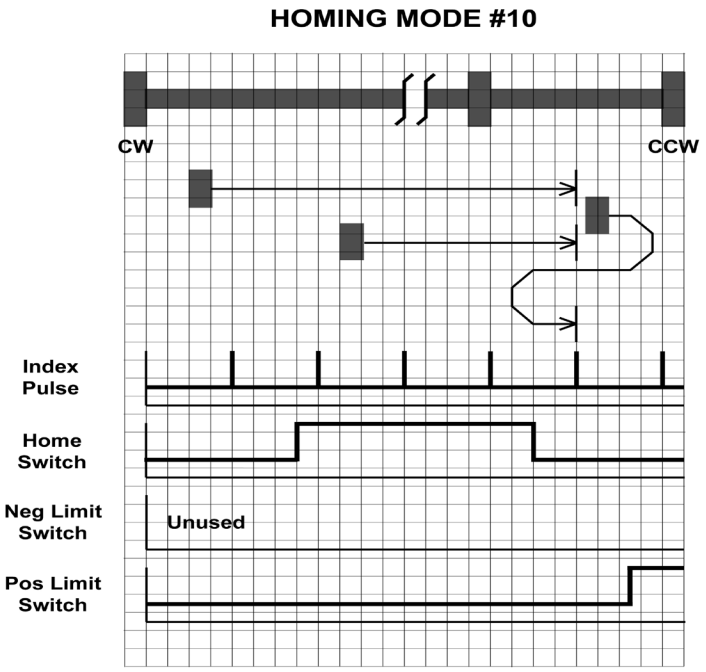
Homing Method 9

Starts moving CCW and homes to the first index CW of the home switch transition.



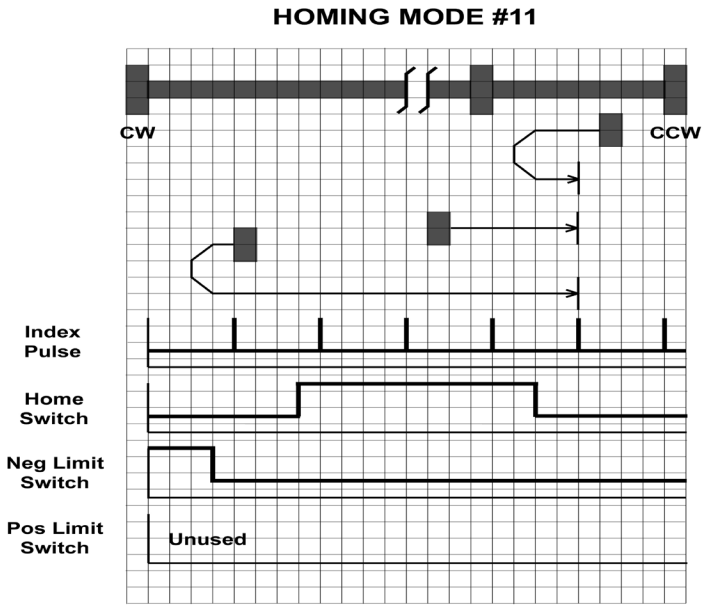
Homing Method 10

Starts moving CCW and homes to the first index CCW of the home switch transition.



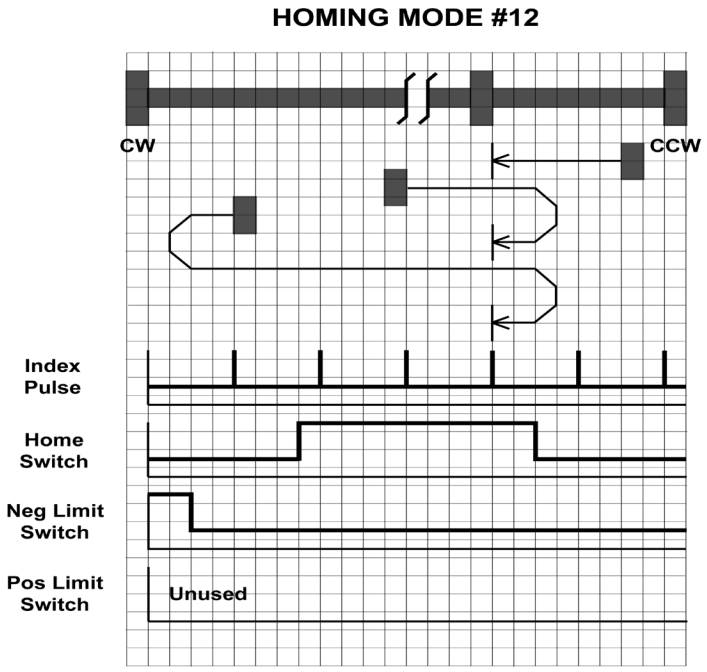
Homing Method 11

Starts moving CW (or CCW if the home switch is active), and homes to the first index CCW of the home switch transition.



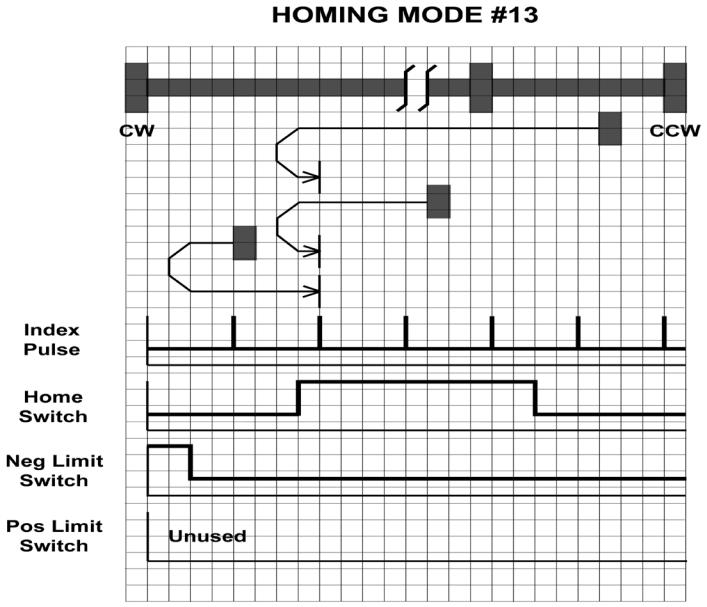
Homing Method 12

Starts moving CW (or CCW if the home switch is active), and homes to the first index CW of the home switch transition.



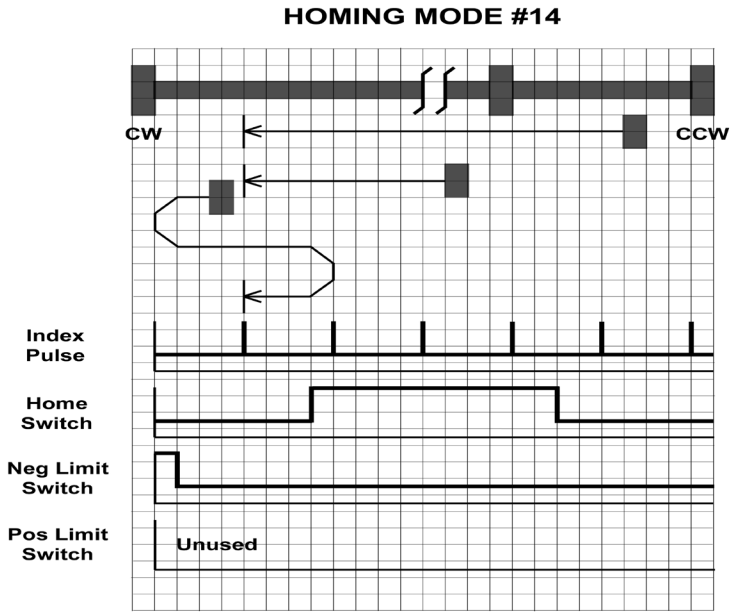
Homing Method 13

Starts moving CW and homes to the first index CCW of the home switch transition.



Homing Method 14

Starts moving CW and homes to the first index CW of the home switch transition shown above.

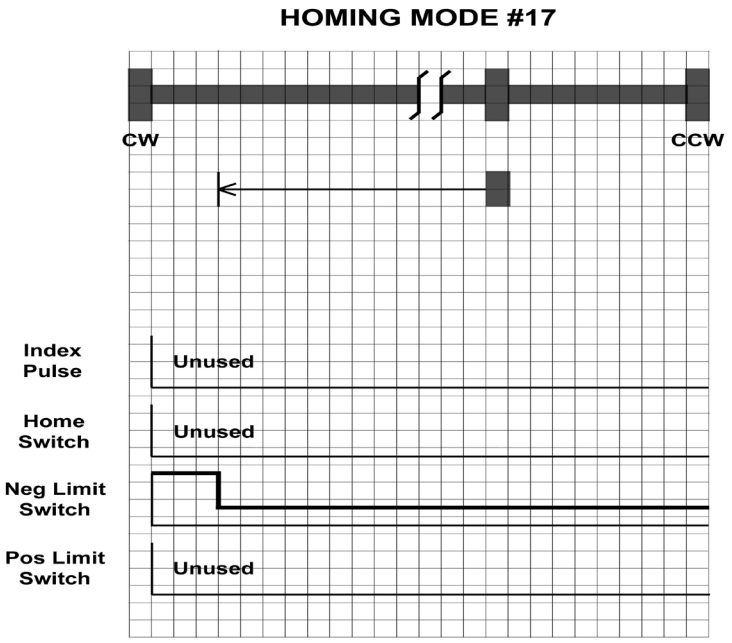


Homing Methods 15 and 16

Homing Methods 15 and 16 are reserved for future expansion.

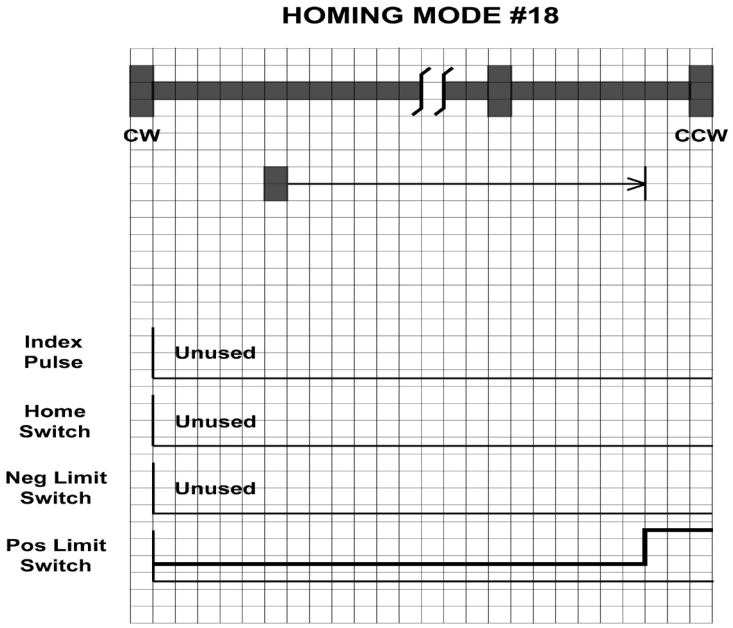
Homing Method 17

Homes to the CW limit switch.



Homing Method 18

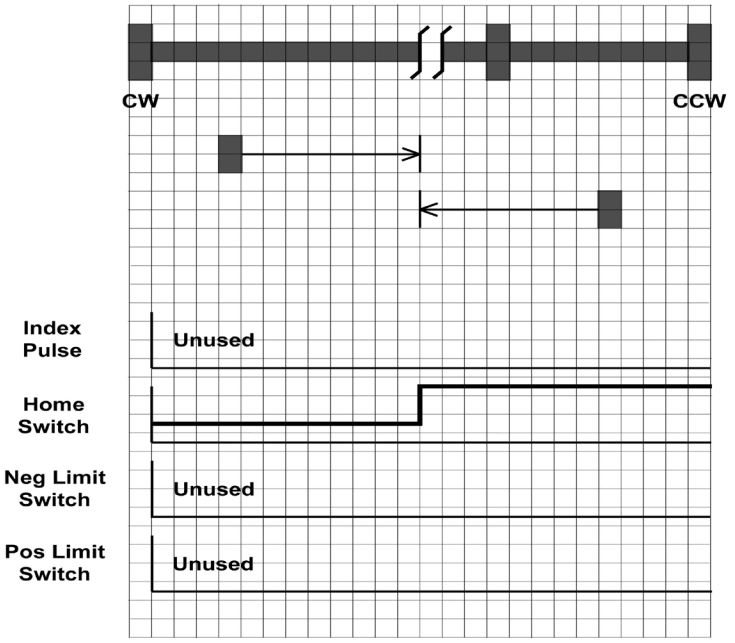
Homes to the CCW limit switch.



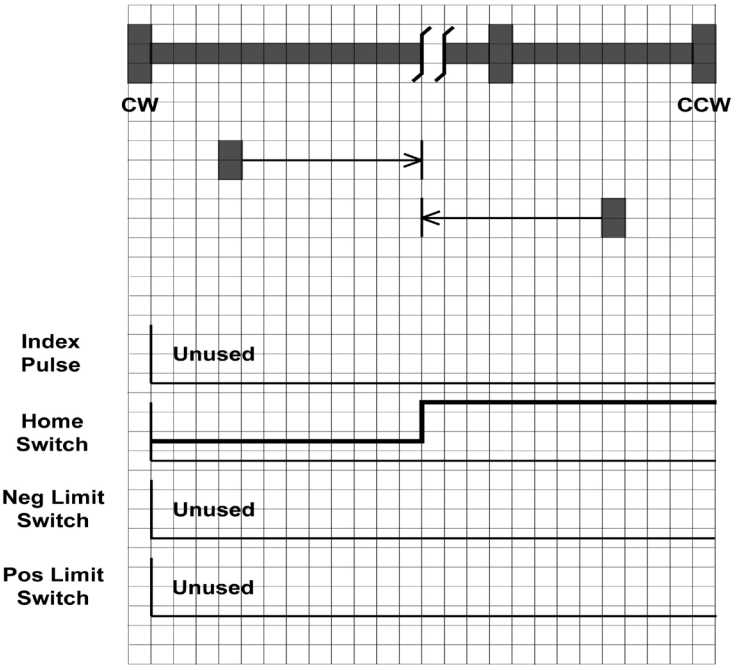
Homing Methods 19 and 20

Home to the home switch transition.

HOMING MODE #19



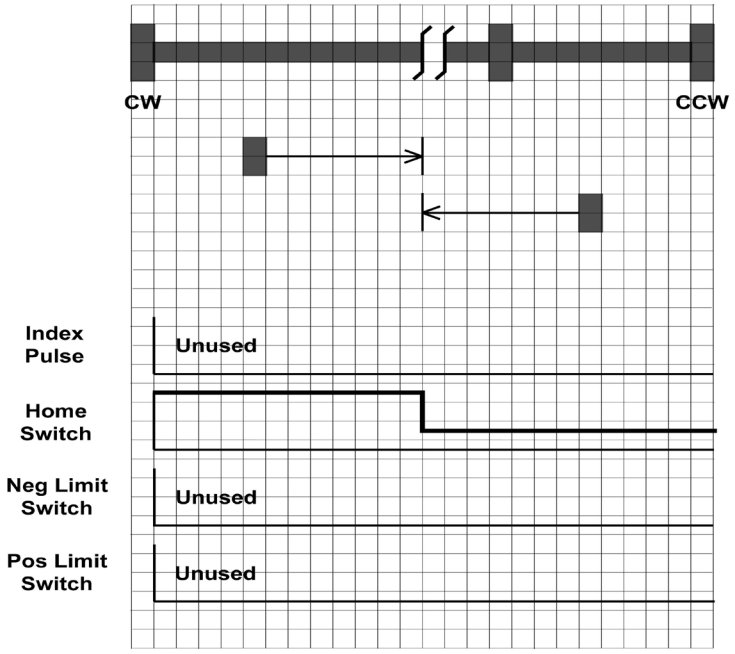
HOMING MODE #20



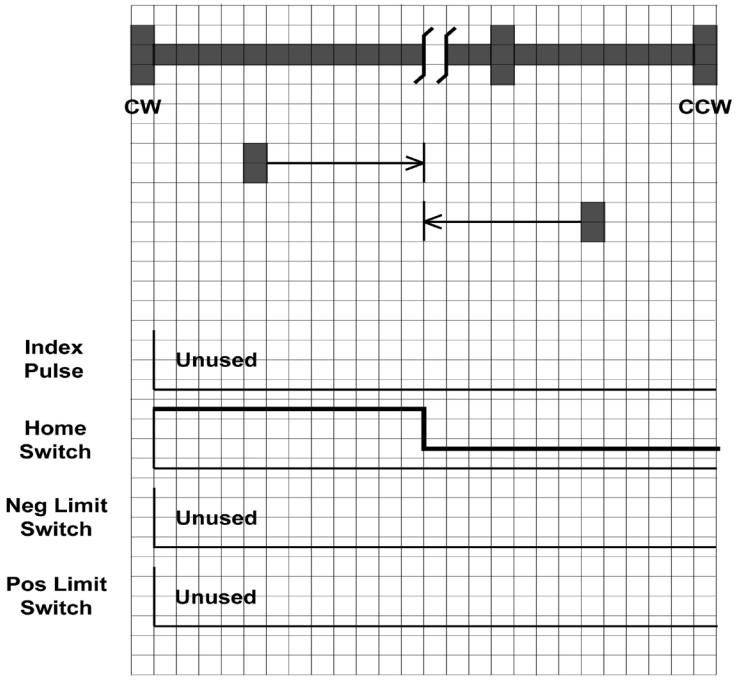
Homing Methods 21 and 22

Home to the home switch transition.

HOMING MODE #21



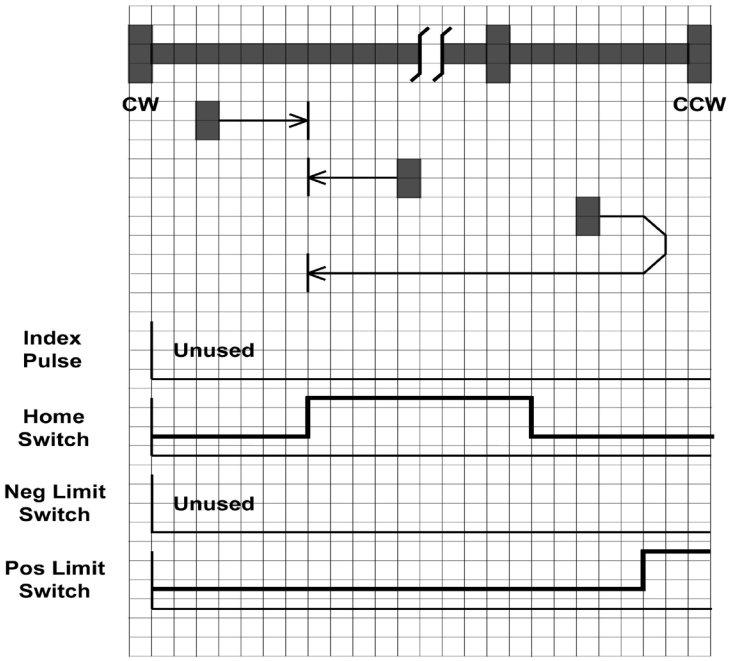
HOMING MODE #22



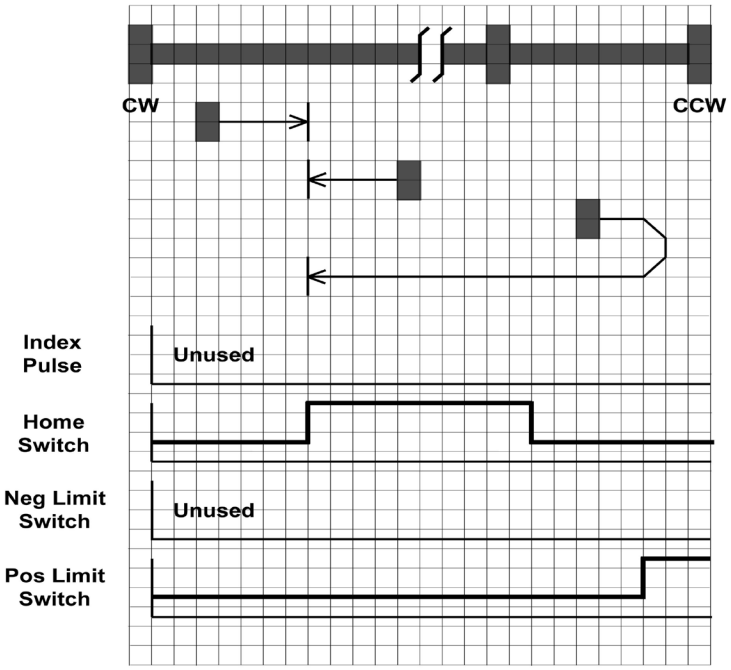
Homing Methods 23 and 24

Home to the home switch transition shown below, and “bounce off” the CCW limit, if required.

HOMING MODE #23



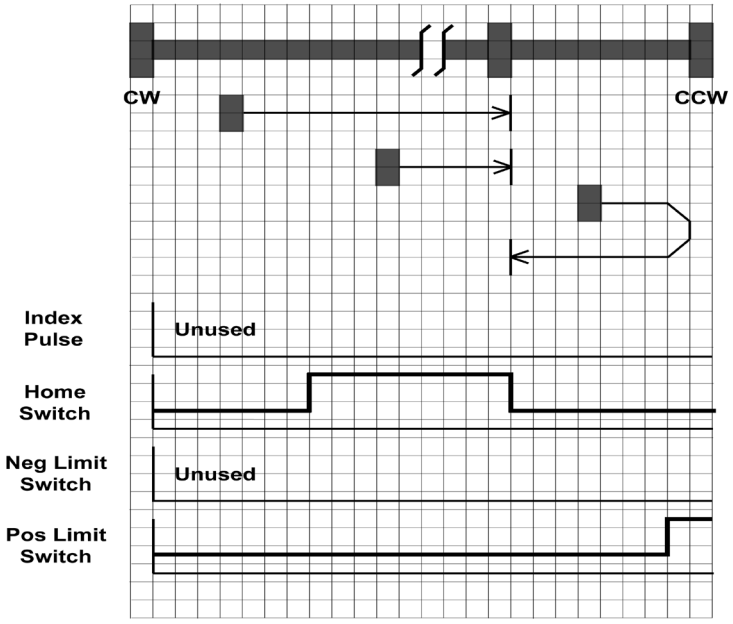
HOMING MODE #24



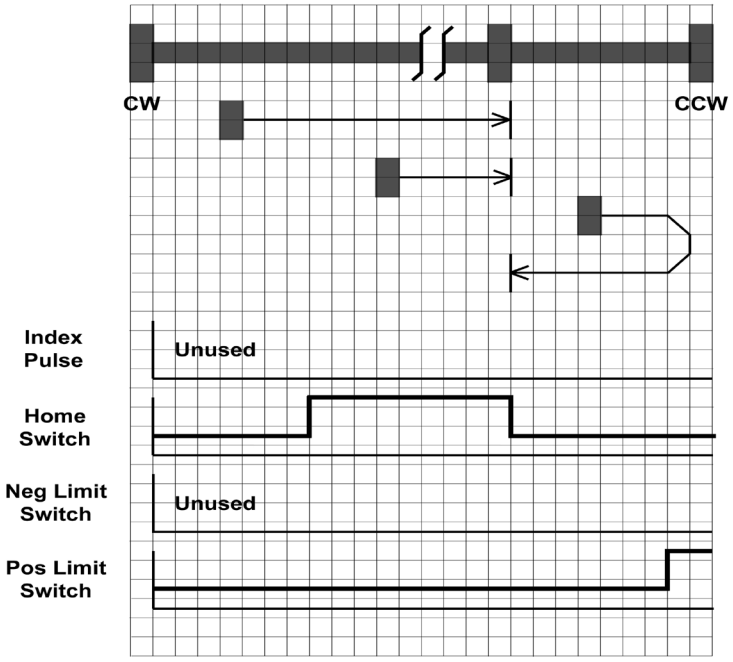
Homing Methods 25 and 26

Home to the home switch transition shown below, and “bounce off” the CCW limit, if required.

HOMING MODE #25



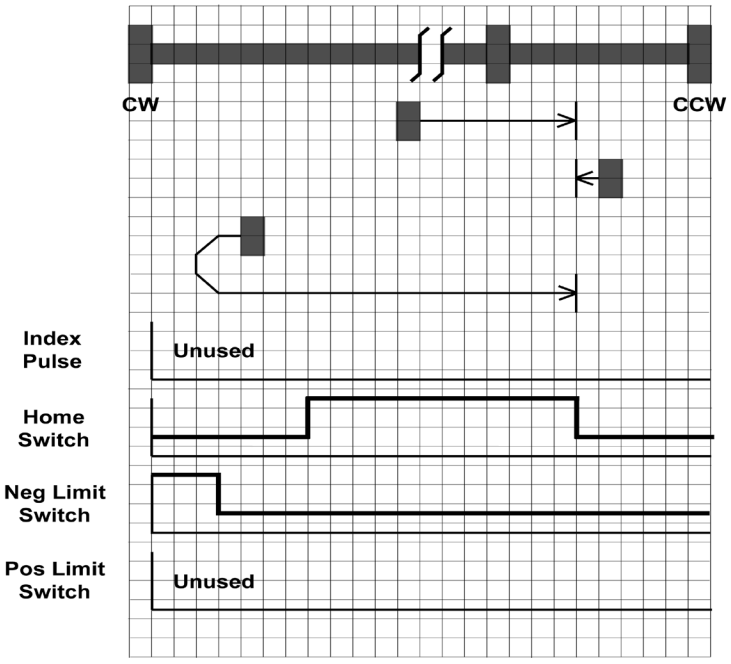
HOMING MODE #26



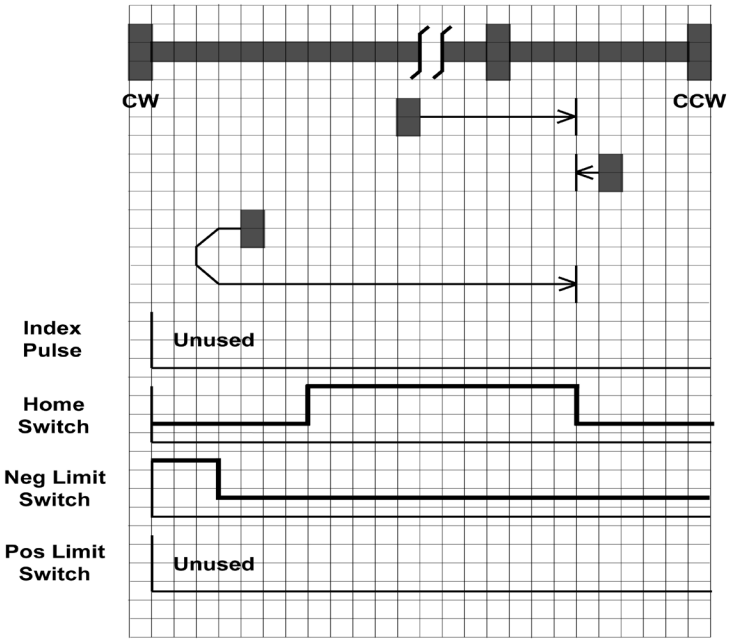
Homing Methods 27 and 28

Home to the home switch transition shown below, and “bounce off” the CW limit, if required.

HOMING MODE #27



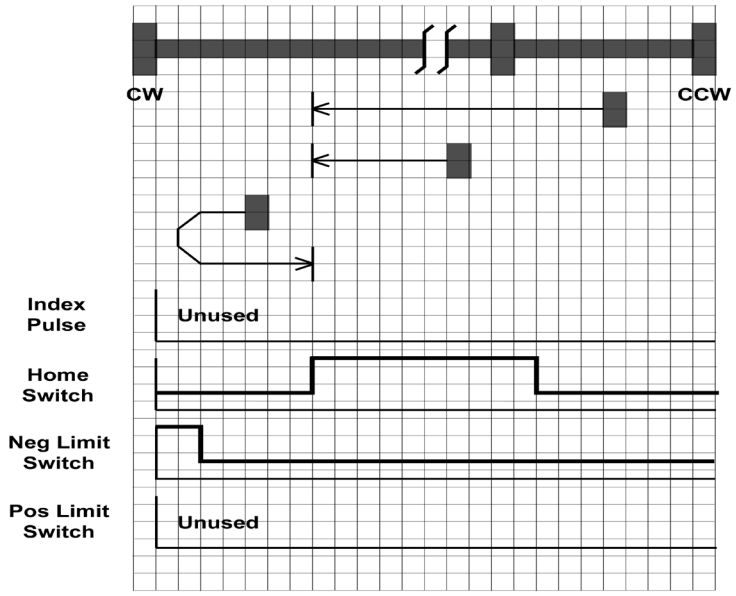
HOMING MODE #28



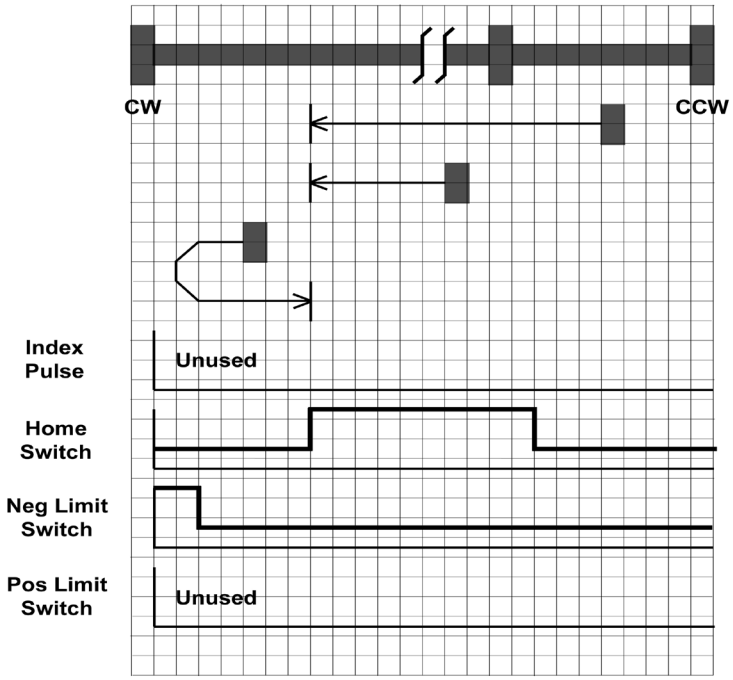
Homing Methods 29 and 30

Home to the home switch transition shown below, and “bounce off” the CW limit, if required.

HOMING MODE #29



HOMING MODE #30

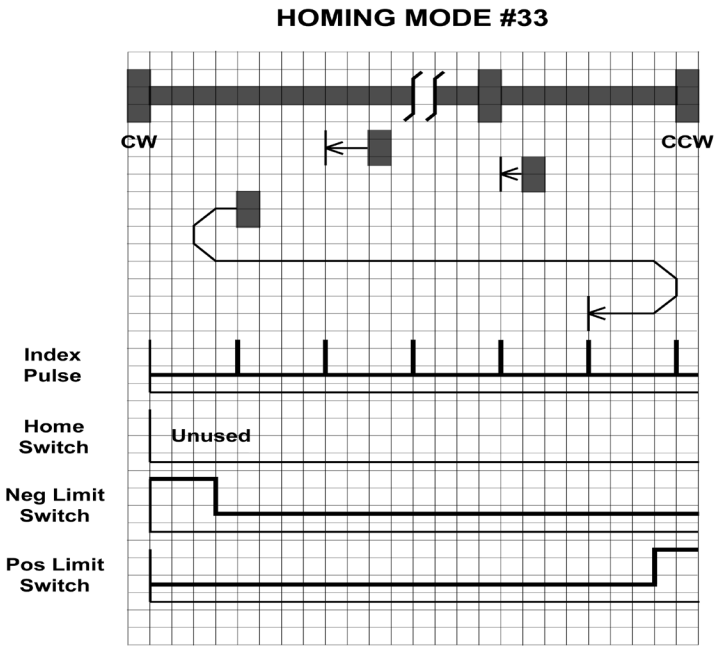


Homing Methods 31 and 32

Homing Methods 31 and 32 are reserved for future expansion.

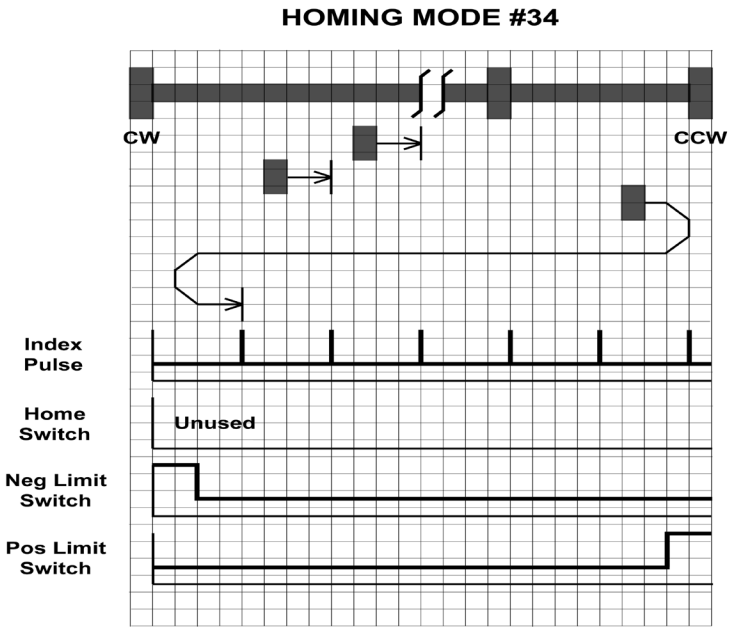
Homing Method 33

Homes to the next index pulse CW from the current position. If the CW limit is hit, the drive resets to the CCW limit, and continues searching for a limit in the CW direction.



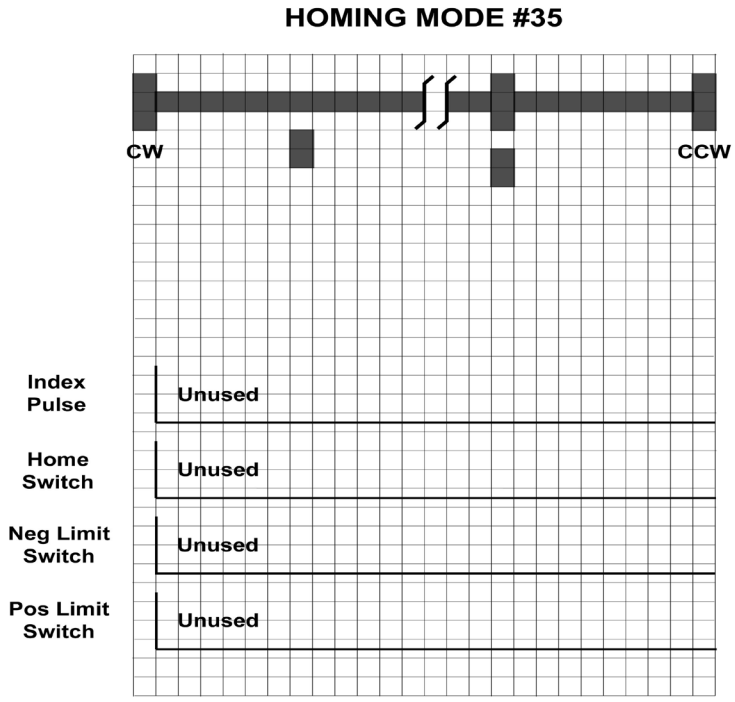
Homing Method 34

Homes to the next index pulse CCW from the current position. If the CCW limit is hit, the drive resets to the CW limit, and continues searching for a limit in the CCW direction.



Homing Method 35

Takes the current position to be the home position; the Home Offset value is ignored, and the motor does not move at all.



Appendix F - Profile Torque Mode (Servo Only)

General Mode Description

Profile Torque mode is a servo-control torque operating mode. It requires knowledge of the Torque Constant of the motor in Nm/A. This information can be found in the motor print.

Enable Profile Torque Mode

To enable Profile Torque Mode, the value 0004_h must be written to the mode of operation OD entry, located at dictionary address 6060_h.

The mode of operation can be verified using OD 6061_h - mode of operation display - which is updated when the current operation mode is accepted.

Set Running Parameters

To operate in Profile Torque mode, the following parameters must be set:

Parameter Name	Object Dictionary Entry	Length (in bytes)	Units	Description
Torque Constant	7005_h	2	$\frac{m \cdot Nm}{a}$	Motor paramter, found on the motor print
Target Torque	6071_h	2	m • Nm	Torque to be applied to the motor
Torque Slope	6087_h	4	$\frac{m \cdot Nm}{sec}$	Rate at which to ramp torque to new target

Figure 11: Set Running Parameters

Enable Drive Operation

After power up or node reset, the drive is in disabled state. The value 0006_h must be written to the control word OD entry, located at dictionary address 6040_h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006_h is not written to the control word first, the drive operation can not be enabled.

To enable drive operation, the value $000F_h$ must be written to the controlword OD entry, located at dictionary address 6040_h. This puts the drive into the Operation Enabled state with no torque applied.

It should be noted that both enabling the halt bit and setting the target torque to zero will ramp down the torque applied to the motor according to the torque slope. At the end of the slope no torque will be applied to the motor, allowing the shaft to move freely.

Starting/Stopping Torque

To start and stop motion, toggle the controlword halt bit (bit 8). When the halt bit is set to 0, motion will start or continue; when the halt bit is set to 1, motion will stop. The bit can be toggled by writing $010F_h$ and $000F_h$ to controlword OD entry 6040_h.

Parameter Calculations - Example

An application requires a torque of 50 oz-in. and a torque slope of 25 oz-in/sec. The motor print lists the Torque Constant of the motor as 0.07Nm/A. The Nm/A constant given must first be converted into mNm/A, as required by the Torque Constant OD entry. The formula used for this is:

$$0.07 \frac{Nm}{A} \cdot 1000 \frac{mA}{A} = 70 \frac{m \cdot Nm}{A}$$

As the drive works primarily in Nm, the desired 50 oz-in of torque must also be converted into Nm, using the conversion factor 141.6 oz-in/Nm.

$$141.6 \frac{\frac{50\ oz\text{-}in}{oz\text{-}in}}{Nm} = 0.3531\ Nm$$

Now, the resultant torque of 0.3531Nm must be converted into mNm, as required by the Target Torque OD entry.

$$0.3531\ Nm \cdot 1000 \frac{m \cdot Nm}{Nm} = 353.1\ m \cdot Nm$$

The result is a value of 353 mNm, rounded to the nearest whole number, for the Target Torque OD Entry.

Finally, the desired slope must be converted from the given units of oz-in/sec into the required units of mNm/sec.

$$\left(25 \frac{oz\text{-}in}{sec}\right) * \left(\frac{1\ Nm}{141.6\ oz\text{-}in}\right) * \left(\frac{1000\ m \cdot Nm}{1\ Nm}\right) = 176.55 \frac{m \cdot Nm}{sec}$$

Rounding to the nearest whole number results in a Torque Slope of 177 mNm/sec.

Current Verification - Example

It is important to check that the current required of the drive is within the limits of the servo amplifier. The drive being used, for example, has a continuous rating of 7 amps, and a peak current of 14 amps, which may be held continuously for 2 seconds. This means that a current of 7 amps can be held indefinitely, and currents between 7 and 14 amps may be used in short

bursts.

Using the target torque and torque constant from the example above the current draw can be checked, as shown:

$$\frac{0.3531\ \text{Nm}}{0.07\ \frac{\text{Nm}}{\text{A}}} = 5.0443\ \text{A}$$

The resultant current, 5.0443A, is below the 7A continuous current rating of the drive, and well below the peak current rating of 14A. It is possible for the drive to maintain a current of 7A indefinitely, and peak up to 14A for up to two seconds continuously. Values between 7A and 14A may be held proportionally long.

For more information: see DSP402 - 2, Profile Torque Mode

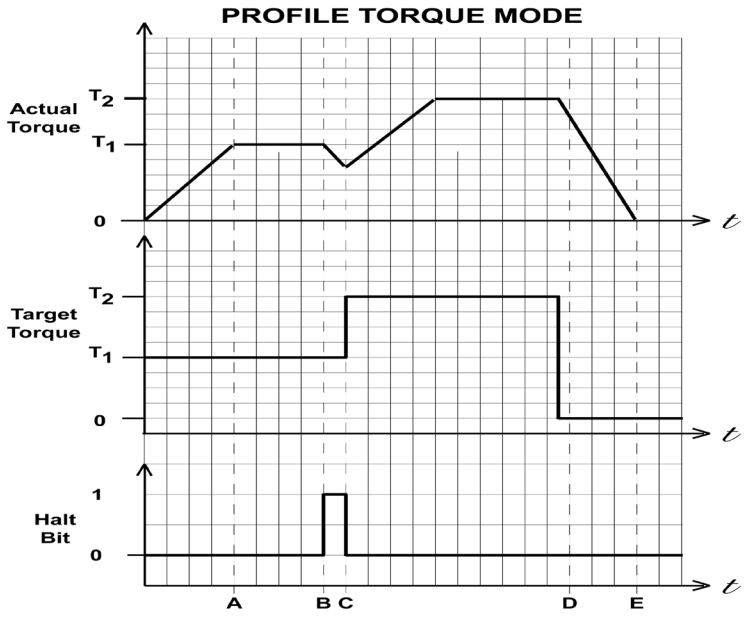


Figure 12: Profile Torque Mode

Graph Point	Target Torque	Halt Bit	Drive command to Motor
Start	T1	0	Ramp torque to T1
A	T1	0	Maintain torque at T1
B	T1	0 -> 1	Ramp torque to zero
C	T1 -> T2	1 -> 0	Ramp torque to T2
D	T2 -> 0	0	Ramp torque to zero
E	0	0	Maintain torque at zero

Table 16: Profile Torque Mode Example

Appendix G - Q Program Mode

General Mode Description

In order to expand the functionality of MOONS' CANopen drives, the Q programming language may be used to execute complex motion profiles that may not be possible within the scope of DSP402. The Q program must be written and pre-loaded into the CANopen drive using Q Programmer (v1.3.5 or later).

Q Programs may also access and manipulate the CANopen General Purpose registers for use in stored programs. The section above on General Purpose Registers has a chart to convert from the OD entry to the Q address.

Loading a Q Program

As with ST Configurator and Quick Tuner, the drive must be powered up with the RS-232 port connected, and Q Programmer running for the CANopen drive to delay the normal boot-up procedure. The CAN boot-up can be resumed by closing the Q Programmer application, or by power-cycling the drive with the RS-232 port disconnected. Once Q Programmer is in control of the drive, it may be used in the same way as any other MOONS' Q drive. See the Q Command Reference for more information on Q programming.

Normal Q Program Execution

To execute a stored Q program on a single drive, a value of -1 (FF_h) must be written to the mode of operation OD entry, located at dictionary address 6060_h. The mode of operation can be verified using OD entry 6061_h - mode of operation display - which is updated when the current operation mode is accepted.

Next, the desired Q segment number, 1-12, must be written to the Q Segment Number register, located at address 7007_h.

After power up or node reset, the drive is in disabled state. The value 0006_h must be written to the control word OD entry, located at dictionary address 6040_h. This will put the drive into "ready to switch on" state and is ready to enable drive operation. If the value 0006_h is not written to the control word first, the drive operation can not be enabled.

To enable drive operation, a value of $000F_h$ must be written to the controlword OD entry, located at dictionary address 6040_h. This puts the drive into Operation Enabled state and ready to run the Q program.

To run the selected Q program, a value of $001F_h$ must be written to the controlword. The Q program will then run to completion. The Q program may be re-executed by a 0->1 transition of the Q Program start bit (bit 4) in the controlword.

To halt execution of a Q program, the halt bit (bit 8) of the controlword must be set to 1. The Q program will halt immediately and start from the beginning the next time a 0->1 transition is seen on the Q Program start bit after the halt bit has been cleared.

Synchronous Q Program Execution

To execute a stored Q program on a single drive, a value of -2 (FE_h) must be written to the mode of operation OD entry, located at dictionary address 6060_h. The mode of operation can be verified using OD entry 6061_h - mode of operation display - which is updated when the current operation mode is accepted.

Next, the desired Q segment number, 1-12, must be written to the Q Segment Number register, located at address 7007_h. To enable operation $001F_h$ must be written to the controlword OD entry 6040_h.

After power up or node reset, the drive is in disabled state. The value 0006_h must be written to the control word OD entry, located at dictionary address 6040_h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006_h is not written to the control word first, the drive operation can not be enabled.

To enable drive operation, a value of $000F_h$ must be written to the controlword OD entry, located at dictionary address 6040_h. This puts the drive into Operation Enabled state and ready to run the Q program.

To run the drive based on the SYNC pulse, the pulse must be set in the COB-ID SYNC register located at OD entry 1005_h. A standard value for the SYNC pulse is 80_h, but any unused COB-ID may be used. Refer to DS301 for a list of reserved COB-IDs.

Once the SYNC pulse has been set, and the desired Q segment has been set, the drive will execute the Q segment every time it receives a SYNC pulse. In this way, multiple drives may be instructed to start a Q program with a single, network-wide instruction.

To halt execution of a Q program, set the halt bit (bit 8) of the controlword to 1. The Q program will halt immediately, and start from the beginning the next time a SYNC pulse is sent after the halt bit has been cleared.

More Information

For more information: see DS301, COB-IDs

For more information on Q programming: see the Host Command Reference on the CD included with the MOONS’ CANopen drive

Appendix H - Understanding NMT States

Under normal operating conditions, a Network Management (NMT) state machine will power up into an Initialization state, send out a boot-up packet, move into a Pre-Operational state, and start sending out heartbeats with the Pre-Operational state status code.

NMT Mode	NMT Control Command	NMT Status Code (Heartbeat)
Initialization/Node Reset	129	0
Pre-Operational	128	127
Operational	1	5
Stopped	2	4

Table 17: Understanding NMT States

Building a CANopen NMT Data Frame - Example

This example will show how to send a broadcast message to all CANopen nodes to put them into an operational NMT state. The COB-ID for NMT commands is always 0. This ensures that an NMT command has the highest priority on the bus and will never be preempted, except by another node sending out an NMT command.

The first data byte of an NMT command contains the NMT Control Command, which is 1 (Operational) in this case.

The second data byte contains either the Node-ID of a target Node, or, in the event that the NMT master is requesting that all nodes change their NMT Mode, a zero. To send a broadcast message, a zero is used.The completed data frame is below.

COB ID	Data Length	Data Byte 0	Data Byte 1
0	2	1	0

Table 18: Example - NMT Data Frame

Appendix I - SDO and PDO Access

Enable SDO Use

To enable Service Data Object (SDO) use, the NMT state must be either Pre-Operational or Operational. Send an NMT message to put the node into either state. When completed, the heartbeat should return either 127 (Pre-Operational) or 5 (Operational). The drive is now ready to read and/or write all OD entries.

Building an SDO Read Data Frame - Example

This example will show how to read the heartbeat time of node $2E_h$. An SDO read request must be sent to the drive. The default COB-ID for SDO requests is 600_h (see DS301), plus the Node-ID of $2E_h$. This results in a specific COB-ID for this message of $62E_h$. The first data byte is reserved for the control byte, which is always 40_h for an SDO Read. The next 2 bytes are reserved for the OD entry address in Little Endian format. To obtain OD entry 1017, we stuff data byte 1 with 17_h and data byte 2 with 10_h. Data byte 3 is reserved for the sub-index of the OD entry, which in this case is zero. The last 4 bytes are unused for SDO reads. The whole message appears as:

COB-ID	Data Length	Data Byte 0	1	2	3	4	5	6	7
$62E_h$	8	40_h	17_h	10_h	00_h	00_h	00_h	00_h	00_h
						DATA BYTES			

Table 19: Enable SDO Use

The drive will respond with a message with COB-ID 580_h + Node ID, or $5AE_h$.

For more information: see DS301, SDO protocol

PDO Access

Enable PDO Use

To enable Process Data Object (PDO) use, the NMT state must be set to Operational and an NMT message sent to enable the Operational state. When completed, the heartbeat should return a 5. The drive is now ready to receive RPDOs, and will transmit TPDOs depending on the Transmission Type.

TPDO Transmission Types

There are several triggering options for Transmit PDOs, which are controlled by OD entries 1800_h to 1803_h, and their associated sub-entries.

Possible TPDO Triggers

SYNC pulse - Node will send TPDO after receiving one or multiple SYNC pulses

Event/Timer - Node will issue TPDO based on an internal event or timer

Remote Request - Node will send TPDO after a remote request

0	PDO transmitted on the next SYNC pulse after the statusword has changed
1	PDO transmitted on every SYNC pulse
2-240	PDO transmitted on every n SYNC pulses
254-255	PDO transmitted every time statusword changes, or the Event Timer has expired

Table 20: TPDO Transmission Types

PDO Mapping - Stepper

PDO Name	First Mapped Parameter	OD Entry	# Bytes	Second Mapped Parameter	OD Entry	# Bytes	# Bytes Total
TPDO1	Statusword	6041_h	2				2
TPDO2	Statusword	6041_h	2	Target Position	6064_h	4	6
TPDO3	Statusword	6041_h	2	Target Velocity	$606C_h$	2	4
TPDO4	Input Status	7003_h	1				1
RPDO1	Controlword	6040_h	2				2
RPDO2	Controlword	6040_h	2	Target Distance	$607A_h$	4	6
RPDO3	Controlword	6040_h	2	Target Velocity	$60FF_h$	2	4
RPDO4	Output State	$60FE_h$	1				1

Table 21: PDO Mapping - Stepper

PDO Mapping - Servo

PDO Name	First Mapped Parameter	OD Entry	# Bytes	Second Mapped Parameter	OD Entry	# Bytes	# Bytes Total
TPDO1	Statusword	6041_h	2				2
TPDO2	Statusword	6041_h	2	Actual Position	$700A_h$	4	6
TPDO3	Statusword	6041_h	2	Actual Velocity	7009_h	2	4
TPDO4	Input Status	7003_h	1				1
RPDO1	Controlword	6040_h	2				2
RPDO2	Controlword	6040_h	2	Target Distance	$607A_h$	4	6
RPDO3	Controlword	6040_h	2	Target Velocity	$60FF_h$	2	4
RPDO4	Output State	$60FE_h$	1				1

Table 22: PDO Mapping - Servo

PDO COB-ID

Because PDOs are directly mapped to OD entries, no overhead is required when working with them. RPDOs may be sent directly with the COB-ID being the default RPDO COB-ID plus the Node-ID. For example, the default RPDO1 COB-ID is 200_h. Therefore, the COB-ID for RPDO1 to Node $2E_h$ would be $200_h + 02E_h = 22E_h$. The default COB-IDs for each PDO may be found in DS301 on page 78.

Building an RPDO Data Frame - Example

This example will show how to set the controlword of node $2E_h$ to $7E4F_h$ using RPDO1. The paragraph above shows how the COB-ID of $22E_h$ was determined. The mapping table above that shows that the first two message bytes will contain the controlword. According to Endianness, the first data byte will be $4F_h$ and the second will be $7E_h$. The entire message will then read:

COB ID	Data Length	Data Byte 0	Data Byte 1
$22E_h$	2	$4F_h$	$7E_h$

Table 23: PDO COB-IDs

For more information on PDO mapping: see DSP402-3

For more information on the PDO protocol: see DS301

Appendix J - Operation Mode Specific Control and Status Word

Control Word of Profile Position Mode

Bit #	Name	Value	Description
4	New Set Point	0	Toggle this bit from 0->1 to clock in a new set point
		1	
5	Change Set Point Immediately	0	Positioning shall be completed (target reached) before the next one gets started
		1	Next positioning shall be started immediately
6	Abs/Rel	0	Target position shall be an absolute value
		1	Target position shall be a relative value
8	Halt	0	Positioning shall be executed or continued
		1	Axis shall be stopped
9	Change of Set Point	0	The previous set-point will be completed and the motor will come to rest before a new set point is processed
		1	The motor will continue at the speed commanded by the previous set point until it has reached the position commanded by the previous set point, then transition to the speed of the new set point

Status Word of Profile Position Mode

Bit #	Name	Value	Description
10	Target Reached	0	Halt (Bit 8 in controlword) = 0: Target position not reached Halt (Bit 8 in controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in controlword) = 0: Target position reached Halt (Bit 8 in controlword) = 1: Velocity of axis is 0
12	Set Point Ack	0	Previous set point already processed, waiting for new set point
		1	Previous set point still in process, set point overwriting shall be accepted
13	Following Error	0	No following error
		1	Following error

Control Word of Profile Velocity Mode

Bit #	Name	Value	Description
8	Halt	0	The motion shall be executed or continued
		1	Axis shall be stopped

Status Word of Profile Velocity Mode

Bit #	Name	Value	Description
10	Target Reached	0	Halt (Bit 8 in controlword) = 0: Target velocity not reached Halt (Bit 8 in controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in controlword) = 0: Target velocity reached Halt (Bit 8 in controlword) = 1: Velocity of axis is 0
12	Speed	0	Speed is not equal to 0
		1	Speed is equal 0

Control Word of Homing Mode

Bit #	Name	Value	Description
4	Homing Operation Start	0	Do not start homing procedure
		1	Start or continue homing procedure
8	Halt	0	Enable bit 4
		1	Stop axis

Status Word of Homing Mode

Bit #	Name	Value	Description
10	Target Reached	0	Halt (Bit 8 in controlword) = 0: Home position not reached Halt (Bit 8 in controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in controlword) = 0: Home position reached Halt (Bit 8 in controlword) = 1: Velocity of axis is 0
12	Homing Attained	0	Homing Mode not yet complete
		1	Homing Mode carried out successfully
13	Homing Error	0	No homing error
		1	Homeng error

Control Word of Q Mode

Bit #	Name	Value	Description
4	Q Program Start	0	Toggle this bit from 0->1 to run Q program
		1	
8	Halt	0	Enable bit 4
		1	Stop axis

Status Word of Q Mode

Bit #	Name	Value	Description
10	Target Reached	0	Halt (Bit 8 in controlword) = 0: Q program running Halt (Bit 8 in controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in controlword) = 0: Q program finishes or not started Halt (Bit 8 in controlword) = 1: Velocity of axis is 0

Appendix K – Example Programs

Profile Position Mode

**** Enable Motor Power - DSP402 State Machine ****

ID	DLC	Data
$0603	$8	$2B $40 $60 $00 $06 $00 $00 $00 'Ready to Switch on
$0603	$8	$2B $40 $60 $00 $07 $00 $00 $00 'Switched on
$0603	$8	$2B $40 $60 $00 $0F $00 $00 $00 'Operation Enabled

**** Set to Profile Position Mode ****

$0603	$8	$2F $60 $60 $00 $01 $00 $00 $00 'Set to Profile Position Mode

**** Set Motion Parameters ****

$0603	$8	$23 $81 $60 $00 $F0 $00 $00 $00 'Set Profile Velocity to 1 rps
$0603	$8	$23 $83 $60 $00 $58 $02 $00 $00 'Set Acceleration to 100 rps/s
$0603	$8	$23 $84 $60 $00 $58 $02 $00 $00 'Set Deceleration to 100 rps/s

Single Move Absolute

$0603	$8	$23 $7A $60 $00 $40 $0D $03 $00 'Set Target Position to 200000 steps
$0603	$8	$2B $40 $60 $00 $1F $00 $00 $00 'Set New Set Point Bit to 1
$0603	$8	$2B $40 $60 $00 $0F $00 $00 $00 'Clear New Set Point Bit

Single Move Relative

$0603	$8	$23 $7A $60 $00 $40 $0D $03 $00 'Set Target Position to 200000 steps
$0603	$8	$2B $40 $60 $00 $5F $00 $00 $00 'Set New Set Point Bit to 1
$0603	$8	$2B $40 $60 $00 $4F $00 $00 $00 'Clear New Set Point Bit

Multiple Move, Stopping between Moves

$0603	$8	$23 $81 $60 $00 $B0 $04 $00 $00 'Set Profile Velocity to 5 rps
$0603	$8	$23 $7A $60 $00 $40 $0D $03 $00 'Set Target Position to 200000 steps
$0603	$8	$2B $40 $60 $00 $5F $00 $00 $00 'Set New Set Point Bit to 1
$0603	$8	$2B $40 $60 $00 $4F $00 $00 $00 'Clear New Set Point Bit
$0603	$8	$23 $81 $60 $00 $60 $09 $00 $00 'Set Profile Velocity to 10 rps
$0603	$8	$23 $7A $60 $00 $40 $0D $03 $00 'Set Target Position to 600000 steps
$0603	$8	$2B $40 $60 $00 $5F $00 $00 $00 'Set New Set Point Bit to 1
$0603	$8	$2B $40 $60 $00 $4F $00 $00 $00 'Clear New Set Point Bit

Multiple Move, Continuous Motion

$0603	$8	$23 $81 $60 $00 $B0 $04 $00 $00 'Set Profile Velocity to 5 rps
$0603	$8	$23 $7A $60 $00 $40 $0D $03 $00 'Set Target Position to 200000 steps
$0603	$8	$2B $40 $60 $00 $5F $02 $00 $00 'Set New Set Point Bit to 1
$0603	$8	$2B $40 $60 $00 $4F $02 $00 $00 'Clear New Set Point Bit
$0603	$8	$23 $81 $60 $00 $60 $09 $00 $00 'Set Profile Velocity to 10 rps
$0603	$8	$23 $7A $60 $00 $40 $0D $03 $00 'Set Target Position to 600000 steps
$0603	$8	$2B $40 $60 $00 $5F $02 $00 $00 'Set New Set Point Bit to 1
$0603	$8	$2B $40 $60 $00 $4F $02 $00 $00 'Clear New Set Point Bit

Multiple Move, Immediate Change in Motion

$0603	$8	$23 $81 $60 $00 $B0 $04 $00 $00 'Set Profile Velocity to 5 rps
$0603	$8	$23 $7A $60 $00 $40 $0D $03 $00 'Set Target Position to 200000 steps
$0603	$8	$2B $40 $60 $00 $7F $02 $00 $00 'Set New Set Point Bit to 1
$0603	$8	$2B $40 $60 $00 $6F $02 $00 $00 'Clear New Set Point Bit
$0603	$8	$23 $81 $60 $00 $60 $09 $00 $00 'Set Profile Velocity to 10 rps
$0603	$8	$23 $7A $60 $00 $40 $0D $03 $00 'Set Target Position to 600000 steps
$0603	$8	$2B $40 $60 $00 $7F $02 $00 $00 'Set New Set Point Bit to 1
$0603	$8	$2B $40 $60 $00 $6F $02 $00 $00 'Clear New Set Point Bit

Profile Velocity Mode

**** Enable Motor Power - DSP402 State Machine ****

ID	DLC	Data
$0603	$8	$2B $40 $60 $00 $06 $00 $00 $00 'Ready to Switch on
$0603	$8	$2B $40 $60 $00 $07 $00 $00 $00 'Switched on
$0603	$8	$2B $40 $60 $00 $0F $01 $00 $00 'Operation Enabled; Motion Halted

**** Set to Profile Velocity Mode ****

$0603	$8	$2F $60 $60 $00 $03 $00 $00 $00 'Set to Profile Velocity Mode

**** Set Motion Parameters ****

$0603	$8	$23 $FF $60 $00 $F0 $00 $00 $00 'Set Target Velocity to 1 rps
$0603	$8	$23 $83 $60 $00 $58 $02 $00 $00 'Set Acceleration to 100 rps/s
$0603	$8	$23 $84 $60 $00 $58 $02 $00 $00 'Set Deceleration to 100 rps/s

**** Start/Stop Motion ****

$0603	$8	$2B $40 $60 $00 $0F $00 $00 $00 'Motion Starts
$0603	$8	$23 $FF $60 $00 $60 $09 $00 $00 'Change Target Velocity to 10 rps
$0603	$8	$2B $40 $60 $00 $0F $01 $00 $00 'Motion Halts

Homing Mode

**** Enable Motor Power - DSP402 State Machine ****

ID	DLC	Data
$0603	$8	$2B $40 $60 $00 $06 $00 $00 $00 'Ready to Switch on
$0603	$8	$2B $40 $60 $00 $07 $00 $00 $00 'Switched on
$0603	$8	$2B $40 $60 $00 $0F $00 $00 $00 'Operation Enabled

**** Set to Homing Mode ****

$0603	$8	$2F $60 $60 $00 $06 $00 $00 $00 'Set to Homing Mode
$0603	$8	$2F $98 $60 $00 $13 $00 $00 $00 'Set Homing Method to 19

**** Set Motion Parameters ****

$0603	$8	$23 $9A $60 $00 $58 $02 $00 $00 'Set Homing Acceleration to 100rps/s
$0603	$8	$23 $99 $60 $01 $F0 $00 $00 $00 'Set Homing Velocity (Search for Switch) to 1rps
$0603	$8	$23 $99 $60 $02 $78 $00 $00 $00 'Set Index Velocity (Search for Index or Zero) to 0.5rps
$0603	$8	$23 $7C $60 $00 $40 $9C $00 $00 'Set Homing Offset to 40000 Steps
$0603	$8	$2F $01 $70 $00 $03 $00 $00 $00 'Set Homing Switch to Input 3

**** Start/Stop Homing ****

$0603	$8	$2B $40 $60 $00 $1F $00 $00 $00 'Homing Starts
$0603	$8	$2B $40 $60 $00 $1F $01 $00 $00 'Homing Stops

Normal Q Mode

**** Enable Motor Power - DSP402 State Machine ****

ID	DLC	Data	
$0603	$8	$2B $40 $60 $00 $06 $00 $00 $00	'Ready to Switch on
$0603	$8	$2B $40 $60 $00 $07 $00 $00 $00	'Switched on
$0603	$8	$2B $40 $60 $00 $0F $00 $00 $00	'Operation Enabled

**** Set to Normal Q Mode ****

$0603	$8	$2F $60 $60 $00 $FF $00 $00 $00	'Set to Normal Q Mode
$0603	$8	$2F $07 $70 $00 $01 $00 $00 $00	'Set Q Segment Number to 1

**** Start/Stop Q Program ****

$0603	$8	$2B $40 $60 $00 $1F $00 $00 $00	'Q Program Starts
$0603	$8	$2B $40 $60 $00 $1F $01 $00 $00	'Q Program Halts

Sync Q Mode

**** Enable Motor Power - DSP402 State Machine ****

ID	DLC	Data	
$0603	$8	$2B $40 $60 $00 $06 $00 $00 $00	'Ready to Switch on
$0603	$8	$2B $40 $60 $00 $07 $00 $00 $00	'Switched on
$0603	$8	$2B $40 $60 $00 $0F $00 $00 $00	'Operation Enabled

**** Set to Sync Q Mode ****

$0603	$8	$2F $60 $60 $00 $FE $00 $00 $00	'Set to Sync Q Mode
$0603	$8	$2F $07 $70 $00 $01 $00 $00 $00	'Set Q Segment Number to 1
$0603	$8	$23 $05 $10 $00 $80 $00 $00 $00	'Set Sync Pulse to 0x80

**** Start/Stop Q Program ****

$80	$0		'Q Program Starts
$0603	$8	$2B $40 $60 $00 $0F $01 $00 $00	'Q Program Halts